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The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
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## *Safeguarding Essential Supplies*

Owing to the absence of control during the last war, the prices of raw materials soared, shortages developed, public administration was at the mercy of the markets and a number of people who had stocks held them to get higher and higher prices and to profiteer at the expense of the country. This state of affairs was consequent upon lack of experience of the effect of large-scale war upon supplies. This time, however, the country was better prepared, and well before the outbreak of hostilities an organisation known as the Board of Trade Supply Organisation was working out plans under the Committee of Imperial Defence. They had prepared measures for conserving and maintaining supplies in time of war and for diverting them to essential war uses. This was largely effected by co-operation with the leaders of industrial organisations. By August 1 last year, the whole of this organisation was transferred to the Ministry of Supply and proceeded in its efforts without any lack of continuity. First of all a complete catalogue was compiled of the number of Controllers it had decided to set up. The Controllers designated were all earmarked and in consultation with them the main officials of each Control had also been selected. The places and actual hotels or rooms in which the Control was to work were decided upon and the bases of policy upon which the Controls were to work were established. Two days before the war started, in contrast to two or three years after the war started in 1914, Orders were made in connection with iron, steel, wool, flax, jute, timber and many other materials.

Fundamentally, those were the plans, but actually much more than planning had been done, because the transition to war involves turning over industry to different uses from those which it is serving in peacetime. This obviously creates an increased demand for certain types of raw materials, and, in the case of iron and steel, very considerable stocks of iron ore had been accumulated by Government purchase. Moreover, this was done without disturbing the normal markets or the normal course of trade. Amongst other raw materials similarly accumulated were aluminium, zinc, mercury, antimony, ferro-alloys, pyrites, sulphur, phosphate rock, potash and amber mica.

Great Britain was well prepared in all these cases when the war started, and it is a matter of interest to consider the supply position of the British Commonwealth as a whole. The Commonwealth is practically self sufficient in the raw materials needed for war. It supplies a very large proportion of the rubber and tin of the world and in other commodities as well its productive capacity has considerably increased since 1914. Rhodesia has opened up copper mines; the Gold Coast is a very large producer of manganese ore; Sierra Leone now has an important iron-ore industry; Canada is producing aluminium; and India has developed a large-scale cotton industry. All these are post-1914 developments, and emphasis can be given to their magnitude by citing a few statistics. Whereas Empire production of copper ore was 85,000 tons per annum in 1914, it is now yearly producing 600,000 tons; lead ore production has risen from 130,000 tons in 1914 to 630,000 tons to-day; nickel has gone up from 20,000 tons in 1914 to 95,000 tons at the present time, and aluminium has experienced an increase from 13,900 tons to a present-day figure of 88,000. Perhaps the most striking of all is asbestos, which has risen from 98,000 to 344,000 tons.

Since the war started, the State, through the Ministry of Supply, has become a trader in a very large way, as it now handles material to a value of £150,000,000 a year. It owns practically all the supplies of aluminium, copper and the other non-ferrous metals, wool, flax and most of the raw materials for fertilisers and molasses. Bulk purchase contracts have been very largely made with Empire producers and the Dominion Governments concerned. Tentative arrangements were negotiated prior to the war and only needed implementation immediately on the outbreak of hostilities. The buying of the Australian and New Zealand wool clips is well known, but similar action has also been taken for the whole of the exportable surplus of the copper and zinc from Canada, Australia, Rhodesia and Burma. The position with regard to aluminium is that the Ministry has bought the whole of the output of Great Britain, the whole of the exportable surplus of Canada, as well as large quantities in the U.S.A. and other countries. Moreover, steps have been taken to increase production both in this country and Canada. Tungsten has been bought in Australia, Burma, New Zealand and elsewhere. A factor of great importance is that steel production at the outbreak of the war was 75 per cent. greater than in 1914. Moreover, with the creation of such plants as the Broken Hill concern in New South Wales, Iscor in South Africa, and the Tata combine in India, the steel production capacity of the Empire has risen from 9,000,000 tons in 1914 to 18,500,000 tons to-day.

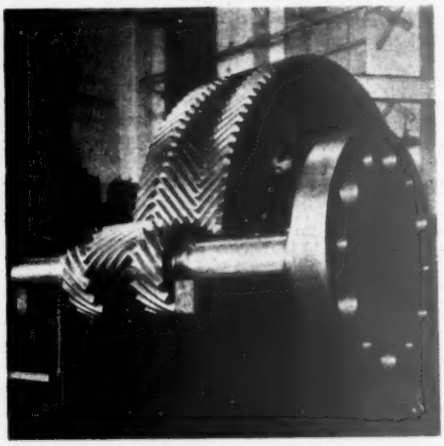
E

In this country, the whole of the iron and steel industry is working as a single unit, pooling all its raw materials. It is far better organised and equipped than it was in 1914, when it was not unusual to find one steel plant would be standing idle waiting for raw material when neighbouring plants possessed an excess. Finally, the complete co-operation with the French authorities is most valuable. We well remember, during the last war, trying to make stainless steel at a large armament works in France, without the essential carbon-free ferro-chrome being available. Though the material was produced in France, every ounce had been bought up by the British Government!

The aims of the Ministry of Supply are primarily to ensure that the essential supplies of raw materials are maintained; to buy them at the best possible prices; to avoid violent fluctuations in price which would be inevitable without controls; to sell the materials at a price which, on the one hand, avoids loss to the taxpayer and, on the other, is fair to the consumer; and to ensure stocks are distributed in such a way as to meet, in the first place, essential war needs.

## Large Winder Gears

The triple helical gears illustrated have recently been completed by David Brown & Sons (Hudd.), Limited, Huddersfield, for a winder in a South African gold mine. The gears, which weigh 25 tons, are designed to transmit a maximum load of approximately 6,000 h.p. The cast-steel wheel is approaching 16 ft. dia. and is



TRIPLE HELICAL GEARS FOR WINDER IN SOUTH AFRICA.

made in halves to facilitate handling and assembly on site, while the pinion is integral with its shaft and is cut from a forging of high-tensile steel. The high-speed coupling is also of interest, as it is 56 in. dia. and is bored 16 in. dia. to accommodate tangential folding keys.

**Flow of Metals**

Great progress has been achieved during the past decade in equipment used for the hot and cold working of steel and other metals. During the same period a similarly important, although less spectacular, development has taken place in academic knowledge of the basic principles underlying the flow of metals in the forming operations. However, the commercial processes offer a considerable resistance to any attempt of developing a theoretical foundation due to the interference of numerous factors. Thus, any mechanical treatment of the plastic flow must allow for the effect of these numerous factors, but must be at the same time simple enough not to extend the unavoidable calculations in a specific case beyond the limits of practical usefulness. A Paper published in "The Iron Age" presents such an attempt to abstract and correlate the present knowledge on the plastic flow of metal. The Paper was originally presented at the recent symposium on the Cold Working of Metals sponsored by the Metallurgy Department of the Carnegie Institute of Technology.

## Book Review

**Engineering Reorganisation** By James J. Gillespie. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 12s. 6d. net.

The author has succeeded in writing a book on the reorganisation of that complex entity, the general engineering works. For this piece of originality alone he deserves special mention; most writers on reorganisation seem to prefer to devote their energies to mass-producing factories.

By plunging straight into his subject without tedious preamble, and giving his definitions, the author applies one of his declared principles: "commence at the logical beginning." However, authors seldom are able consistently to live up to their own teaching, for in the same chapter that we are asked to refrain from the use of hackneyed phrases ("we beg to remain") the reader is presented in the text with a similar one, "last but not least."

The principle of clarity, which is also advocated, is not always honoured. Some sentences are awkward or quite obscure in meaning. Irritating as this obscurity is, no doubt the cause is a praiseworthy desire to say a great deal in a few words. Group Relation charts, Fig. 1 and Fig. 61, are obviously important, but they are by no means as self-explanatory as the author seems to think.

Nevertheless these faults are really only superficial and those who read carefully, and take the trouble to grasp the true significance of what they read, must be struck with the soundness of the ideas expressed and convinced by the common-sense outlook adopted.

The broad-minded approach which characterises the whole book is heralded in the first chapter with the words: "If decisions on new codes and procedures arising from the application of logical method to business affect the human factor, they should be so applied that they fit into group psychological structure."

Sections are devoted to the discussion of such subjects as: Quality and Quantity of Management; the Idea of Central Planning; Effective Identification; How Much Inspection?; To Process or not to Process, and Sales and Office Methods. Valuable hints are given on the organisation of the drawing office, purchasing, stores, time study and rate fixing department and the like. Schemes are drawn up covering effective material control; planned maintenance; costing; accounting; financial and operating analysis and control.

If anyone can really profit from someone else's experience, both theoretical and practical, then to the would-be organiser this book should prove a wise counsellor. How much grief might have been prevented in industry if the following sage advice had been adopted: "Clear up technical considerations before letting loose the hounds of time study and rate fixing"; or to quote another example: "Sharing the credit for work done will get maximum co-operation. To be frank, in more than 50 per cent. of the companies the writer has been in, the ideas put forward and gladly welcomed by the directors were, in large part, ideas that had previously been put forward by various executive officials, but had been ignored or shelved. Although organisers and efficiency experts do not in writing say so, the truth is that a large part of an organiser's work is really the integration of existing ideas into a logical whole and then selling these ideas to the directorate."

In this present work there is no direct reference to the foundry, the author having dealt with it separately in an earlier book; still, there are few foundrymen interested in management who could fail to be stimulated by the shrewd observations of the author. The make-up of the book is neat and the format generally good.

A. J. SHORE.

## Random Shots

One cannot help noticing how many of the A.R.P. signs in the streets are being made of vitreous enamelled sheets. Besides providing that industry with its own modest share of war orders, it is a sure indication that the Government is legislating for a long war. It is to be hoped, however, that the war won't last as long as the vitreous-enamelled sign can be expected to!

* * *

The death of Mr. Ward, of Long Melford, Suffolk, recalls a frequent practice in the conduct of his business, which has special interest now that there is once more a hue and cry for scrap. Much of the work in his foundry was necessarily for the Suffolk farmers, and it was his custom often when delivering castings to take away any scrap iron lying about the farm in part payment. Besides ensuring a good local supply of scrap for use in his own foundry, it must have done much to keep many farm premises neat and tidy. "Marksman" wonders whether East Anglia may prove a particularly unproductive source of scrap in the present campaign as a result.

* * *

A foundry in the desert is something not usually visualised by a foundryman, even in his wildest flights of imagination, but such is the position of a foundry erected a few years ago in Palestine. What is more, this very modern concern possesses a fettling shop, complete with shot-blast chambers, tumbling barrels and the like, in the best approved style. Yet one would imagine that all that the fettling department would have to do would be to arrange the castings in neat rows in the backyard and wait for a convenient sandstorm to arise.

* * *

Last week's JOURNAL can surely lay claim to being the Editor's own private "special number." Over a period of two centuries, apparently, there are only five Thursdays in February, falling in the years 1816, 1844, 1872, 1912, 1940, 1968, and 1996. That issue, then, is the only one that the Editor has "put to bed" on February 29. "Marksman" understands that he was not Editor in 1912, and the next chance falls in 1968. It is hardly likely—so he says—that he will be still at the editorial desk in that year!

* * *

"It is a confusing world," sighed a youngster one day. "In the geography lesson this morning we were told that in America time is several hours behind time at Greenwich, and I always thought that everything moved so fast there! Then the teacher said to Mary 'When do we put the clocks back?' and when Mary said 'When they are fast, I expect,' teacher was cross!"

* * *

Mr. H. H. Shepherd's monthly letter to the East Anglian Section of the Institute of British Foundrymen also has a schoolboy story worth recording.

Father: "I had a note from your teacher to-day."

Son: "O.K. Dad. I won't tell mother!"

"MARKSMAN."

## Catalogue Received

**Machine Tools.** We have received from William Asquith, Limited, of Halifax, a 28-page well-illustrated catalogue covering a wide range of machine tools specially designed for manufacturing aircraft. It is pleasing to see that this newest of all industries relies almost exclusively on aggregations of cast-iron components for making its essential machine tools.

# Copper in Cast Iron*

By TOM BARLOW†

Alloy irons are undoubtedly becoming of increasing importance both to the engineer and to the foundryman, although in innumerable cases unalloyed irons are used successfully. There is a growing tendency on the part of the engineer to demand either special physical properties or soundness in increasingly intricate designs, and for both of these purposes foundrymen have learned to depend more and more on various alloys. Unfortunately, no cure-all has yet been found, and until that time comes, it is necessary to have at least a general knowledge of the effects of the individual elements in order to use them most economically. After all, economy is an essential part of metallurgy and of good foundry practice. Alloys or combinations of alloys are worth while in the foundry only when they can increase the profit, decrease the loss, or otherwise show an increased economy for the foundryman or the engineer.

Engineers do not, and will not, write costly specifications unless they are convinced that the increase in physical properties or engineering properties is actually saving them money. Likewise, the foundryman cannot use alloys unless he offsets their cost either by an increase in the selling price or a decrease in the other foundry costs.

Until recently, the use of copper in grey cast iron had received very little publicity, although copper cast irons have had extensive use for many years. That the use of copper in the foundry has grown strictly on its own merit speaks well for its value to the foundryman. Nevertheless, the copper producers, who have been co-operating for the past eight years to determine, among other things, the effect of copper in alloy cast iron, have now set up a service and development office to make this information available. From a long programme of research at Battelle Memorial Institute in Columbus, Ohio, sufficient data are now available to show what copper does when added in small percentages to grey cast iron. This research is, of course, being continued because it is only by research that the metallurgist can keep in step with the increasing demands of designing and mechanical engineers.

### Mild Chill Reducer

Copper in cast iron is essentially a mild graphitiser or chill reducer. Its effectiveness in this regard can be estimated from the following relative empirical values for graphitising power: Silicon, 1.0; aluminium, 0.5; nickel, 0.3 to 0.4; copper, 0.25 to 0.35; manganese, − 0.25; molybdenum, − 0.35; chromium, − 1.00; vanadium, − 2.00 to − 4.00.

Manganese, chromium, molybdenum and vanadium have negative graphitising values, as they are carbide stabilisers and have an effect on chill opposite to that of copper.

Although the relative graphitising values just given are the best obtainable and are based on recent research in America and in Europe, they must be used with discretion, taking into account the characteristics of the individual elements as well as the basic analysis of the cast iron. For example, silicon up to nearly 3 per cent. acts as a softener or graphitiser in ordinary cast iron, regardless of the original microstructure of the iron. (This graphitising effect is much more pronounced than the strengthening effect of the silicon on the ferrite, but under some circumstances, particularly in very low carbon iron, the strengthening effect of the silicon can be utilised.) However, silicon not only breaks down carbide and reduces chill, but at the same time tends to break down pearlite to give free ferrite, thereby graphitising all sections of the casting, with a corresponding weakening effect on the heavier sections together with increased porosity and poor wear resistance. Frequently, shrinkage trouble results when silicon is added in excess of the amount required to maintain a pearlitic structure in the section involved. When silicon is used to graphitise thin sections to eliminate chill, the heavier sections of the castings are almost invariably softened beyond the point of pearlite and frequently show porosity.

The chill reducing effect of copper is utilised in many applications, particularly in light castings to be machined. For example, in small pistons it is often difficult to maintain the desired degree of machinability in the light sections and simultaneously obtain the required density in the heavy lug sections of the same casting. Copper up to 1.5 per cent. has proved very effective in such cases. There are many similar applications in which copper is used successfully as one method of eliminating an annealing treatment of grey iron castings to maintain the proper degree of machinability. When the use of copper prevents scrap or eliminates the necessity for heat-treatment, the cost of the copper is more than compensated for by a reduction in scrap losses or heat-treating costs.

### Pearlite Stabiliser

Copper has practically no effect on the breakdown of pearlite. Although it reduces chill in the lighter sections, it does not weaken or soften the heavy sections of the same casting. Thus it has an evening or levelling effect that is utilised in castings of intricate design in which it is desirable to maintain uniform properties throughout the castings, regardless of the changes in the section size. Because copper is effective in breaking down excess carbide, reducing chilled corners, and eliminating hard spots in cast iron, it reduces the hardness of light sections which would otherwise tend to be mottled or white. At the same time, copper strengthens and hardens the pearlitic matrix of cast iron and refines the graphite structure in heavy sections. When copper is added to a casting having both heavy and light sections, it promotes greater uniformity in both physical properties and structure throughout the casting. It is therefore referred to as decreasing the section sensitivity, increasing section uniformity, or "stabilising" the pearlitic structure.

A quotation from a recent Paper by McCarrol and McCloud of the Ford Motor Company,* which uses nearly 6 tons of copper per day in alloy steel and iron castings, illustrates the pearlite or structural stabilising effect admirably.

They say that for cylinder blocks it is generally recognised that the hardness in the bore must be maintained high enough to resist wear of piston rings, and it is found that copper additions make such iron more machinable. The graphite also has a more finely divided character; copper has what may be described as a stabilising effect on the graphitisation of carbon. This is evident in the diminishing chilling effect on thinner sections adjacent to more massive ones, and a general tightening of the structure in these heavier sections.

The same authors cite, as a definite example, that copper aids in making sounder castings around valve ports without too great hardness in the bore sections. If this was achieved by lowering the carbon, a tendency to cracks would be approached; to achieve this, on the other hand, by increased silicon is to induce too much "openness" or porosity. They found copper was even more satisfactory than nickel for these effects and at less cost.

The structural stabilising effect of copper is equally applicable to many other castings requiring density, machinability and uniformity, such as pressure castings, pump castings, machine-tool castings, flywheels, cylinder heads, sheaves, pulleys and gears. Another quotation from the Paper by McCarroll and McCloud in regard to flywheel castings illustrates the beneficial effect of copper on density: "In a flywheel, the sections are so great that some element must be introduced to 'close the grain.' As has already been pointed out, copper accomplishes this better than a low silicon content since the copper does it without sacrificing any machinability."

### Chill Controller

Another application of the graphitising effect of copper developed by the Ford Motor Company also is becoming of increasing importance to the foundryman. This use of copper is typified by the Ford camshaft. The prime requisite for this casting is accurate control of the chilling tendency so as to give a white cam tip and a grey shaft without the use of external chills. This is done by replacing a large percentage of silicon by copper. To quote again from the Paper by McCarroll and McCloud, "The use of copper lessens any innate tendency for the swing in either direction (referring to a change in chill depth); in fact, it is quite common for the foundry to operate day after day without additions of either of the alloys ferro-chromium or ferro-silicon in the ladle."

To foundries other than the motor-vehicle, this characteristic of copper is significant in that it provides a means to iron out and eliminate the variations in chill and Brinell hardness due to the normal fluctuations of the chemical composition during a day's run in the cupola or electric furnace. For example, in chilled sprockets, the use of copper to replace a percentage of the silicon promotes greater uniformity in the chill depth around the circumference of the casting and from one casting to the next. The use of 1.0 per cent. copper in this type of casting is normally accompanied by an increase in strength of approximately 20 per cent. in addition to an increase in the uniformity of strength in a single heat and from one heat to the next. There are many other similar applications in which the increased uniformity and better control of analysis due to the use of copper can be realised with economy.

### Strengthener

It is not usual to think of a graphitising element such as copper as a strengthener; and, in fact, copper itself is not a strengthening agent to the same extent that molybdenum, vanadium and chromium are. However, due to the characteristics of copper, it is valuable as a strengthening agent in some applications. Copper hardens and strengthens the matrix of cast iron so that even when used solely as a graphitiser or chill reducer, it does increase the strength somewhat. In this respect, copper differs from silicon, which is a more potent graphitiser but tends to reduce the tensile strength rather drastically. Exceptions to this rule include the use of silicon primarily as a "deoxidiser," and its use in low-carbon irons of such an analysis that the strengthening effect of the silicon on the ferrite becomes of importance. Even in these two exceptions, however, silicon has a tendency to induce porosity in the heavier portion of a casting of unequal section.

The strengthening effect of copper can be utilised in many ways. In the first place, the use of copper as an addition to cast iron in percentages sufficiently great, for example, 2, 2.5,

(*Continued on page* 182.)

* Extracted by courtesy of the Editor of "The Iron Age" from that Journal.

† Engineer, Copper, Iron and Steel Development Association, Cleveland, Ohio.

* "Ford Alloy Castings," by R. H. McCarroll and J. L. McCloud. "Metal Progress," 1936.

# When Bells Were Cast in Churches

By J. R. NICHOLS

In earlier times it was a common practice for bells to be cast "on site," and the itinerant bellfounder was doubtless a fairly familiar figure in the rural districts. The obvious reason for the casting of bells—particularly heavy ones—on site was the elimination of transport and its attendant difficulties in those days of bad roads. In the Eastern Counties the waterways were used in preference to the roads when it became necessary to transport a heavy bell, and also they were used to convey the necessary materials to the temporary foundry set up by the itinerant bellfounder. Ancient records provide ample proof of the casting of bells in churchyards or in adjoining fields or gardens, and in some cases bells were even cast in the church itself! In England, masses of bellmetal have been discovered in or near churchyards, and sometimes the remains of furnaces have been revealed.

This casting "on site" is rather interesting, insomuch that it would appear to apply mainly to church bells; probably the only other large castings made away from a fixed foundry were cannon, in the days when bronze cannon were used. For their own convenience, even those bellfounders who owned a fixed foundry would occasionally go "on tour," in order to execute one or two specific orders, and would pick up any other work that happened to come their way in the course of their journeyings.

### Commercial Procedure

Having received instructions to make a new bell or to recast a damaged one, the first step would be the preparation of an agreement between the founder and the parishioners, a nominal sum generally being paid to clinch the bargain:—

"pay'd ye Bellfounder in earnest .. 10-0."
(Buckden, 1627)

this being but one of many such examples. Sometimes the parish would provide the metal (this, of course, being so in the case of a recasting, where an allowance would be paid to the bellfounder for any addition of metal) and the founder would undertake to cast the bell at an agreed figure per hundredweight. Alternatively, the founder would provide all necessary metal himself. The next thing would be to obtain the use of a field or other place in which to erect his temporary furnace, and in this connection he would often employ local labour to get the materials together and to build the furnace under his supervision.

### A 17th Century Invoice

One of the most complete records of the casting of a sizable bell "on site" is that relating to the "New Castinge of the Great Bell" of Wimborne Minster in 1629. Some of the more interesting items are given below:—

| | £ | s. | d. |
|---|---|---|---|
| *Item.*—Gave to, and spent uppon Anthonye Bond the Bellfounder at his first cominge ... ... | | 1 | 8 |
| *Item.*—For mettle for the great Bell ... | 17 | 8 | 6 |
| *Item.*—For Bricks to make the ffurnace | | 16 | 4 |
| *Item.*—To Henry Allen and his sone for their Garden to melt the great Bell in ... ... ... ... | | 15 | 0 |
| *Item.*—For wood in all to melt the great Bell ... ... ... ... | 1 | 19 | 0 |
| *Item.*—For clearing of the same wood ... | | 6 | 0 |
| *Item.*—For bringinge pte of this wood to the ffurnace ... ... ... | | 3 | 0 |
| *Item.*—To Richard Strickland for 2 Axces for the traules wch carried the great Bell to the ffurnace ... | | 1 | 4 |
| *Item.*—To Heulett for lendinge his schopp and tooles to the Bellfounder and for helpinge him ... ... | | 5 | 0 |
| *Item.*—To James Purchase for 4 dayes worke to helpe the Bellfounder about making the newe wheele, the Roler and Pullyes ... ... | | 4 | 0 |
| *Item.*—Paid to Anthonye Bond the Bellfounder and for him for his wages for newe casting the great Bell at 6s. 8d. the 100 it wayinge thiertye hundred and a halfe ... | 10 | 3 | 4 |

The total cost of recasting this bell, which weighed over 30 cwts., was £35 16s. 3d.

In the early part of the 14th century the great bell of St. Albans, called "Amphibalus," was recast in the hall of the sacristy, and in 1591 a bell was cast in the church of Kirkby Malgcard (Yorks), the parish register recording this as follows:—

"For pareing the Church where the Bell was casten, ij *s.*"

At South Littleton (Worcs) a bell was cast beneath the tower, but one of the largest bells of which we have records showing that it was cast "on site" was a former "Great Tom" of Lincoln. This bell, which weighed over 80 cwts., was cast in the Minster Yard in 1610 by two well-known bellfounders working in temporary partnership, Oldfield of Nottingham and Newcombe of Leicester. Since both these men were proprietors of established foundries and were known to be excellent craftsmen one wonders why this partnership came about; perhaps each thought the job too big to handle individually, or maybe the Dean and Chapter deemed it a better plan to have two well-known founders working in collaboration in what was undoubtedly a big job. A satisfactory casting resulted, for the Minster records state that the bell was "cast and hung upp and upon Sonday the xxvij of this month (Jan. 1611) range owte and all safe and well."

At St. Breward (Cornwall) a "ring" of four bells was recast into one of five in a small garden just outside the churchyard fence in 1758, and at St. Neot, in the same county, a nearby orchard served as a temporary foundry, while at St. Buryan, again in Cornwall, the registers give interesting details of expenses incurred for material for building the furnace, making the mould, etc., on the occasion of the casting of the tenor bell in 1738. A similar state of affairs also existed on the Continent, and in France the *fondeur ambulant* went about casting bells where and when required until as late as the middle of the last century. Berthelé, an ardent French campanologist, gives numerous accounts of the casting of bells on site in France, and mentions that in the case of a particularly large bell 120 men were employed.

### Gold and Silver Additions

No doubt the casting of a bell by an itinerant founder provided a spectacle that would long be remembered by the villagers, who had for months past been looking forward to this important event in their communal life, and towards the completion of which they had been enthusiastically gathering together a miscellaneous collection of more or less suitable metal. With the passage of time such metalware as they were able to contribute lost nothing in value, and the particularly fine tone of many an old bell would be accounted for in later days by the profusion of gold and silver vessels and ornaments that the nobility cast into the furnace at the time of the casting! Local legend has always been fond of attributing the fine tone of a bell to such an alloy, and when a recasting became necessary the parishioners would often insist on the operation actually taking place under their own eyes.

In olden times the casting of a bell within the precincts of a religious house was accompanied by much ceremony, and Southey, in "The Doctor," gives us a glimpse into the procedure:—"The brethren stood round the furnace, ranged in processional order, sang the 150th Psalm, and then, after certain prayers, blessed the molten metal, and called upon the Lord to infuse into it His grace, and overshadow it with His power, for the honour of the Saint to whom the bell was to be dedicated, and whose name it was to bear."

Henry Bagley, an 18th century bellfounder, in a catalogue published in 1732, expressed his willingness to cast bells where required:—"N.B.—The said Henry Bagley (if desired) will cast any Ring or Rings of Bells in the town they belong," and in 1762 the great bell of Canterbury Cathedral, weighing 70 cwts., was cast "on site" by the Whitechapel Foundry.

## Copper in Cast Iron

(*Continued from page* 181.)

or 3 per cent., results in an increase in tensile strength of from 4.4 to 6.6 tons per sq. in., particularly in low-silicon cast iron. Presumably in those percentages, the strengthening effect of copper on the matrix overbalances the weakening effect of the additional graphite formed.

Foundrymen are using copper increasingly in combination with other alloying elements for strengthening purposes. The ability of copper to refine the graphite, increase density and decrease the section sensitivity, combined with its beneficial effect on machinability and chill, warrants its use in combination with such carbide formers as molybdenum, vanadium and chromium. In these combinations, copper increases the machinability, density and toughness of the cast iron without detracting from the beneficial effects of the carbide-forming elements on the physical properties. The use of copper in combination with molybdenum, vanadium and chromium frequently is responsible for an increase in strength greater than that due to the carbide-forming element itself, or from the copper alone. In fact, combinations of alloying elements frequently give different results from what may be expected from a summation of the effects of the individual elements. For example, when copper is added to a molybdenum or vanadium cast iron, it apparently becomes a very definite strengthening element in addition to its effect on machinability and density. This is also true to a somewhat less extent when copper is added to chromium cast iron, although in this case the copper is almost invariably added for its softening and chill reducing effect.

### Hardening Alloy

Although copper decreases chill in thin sections and reduces hard spots or excess carbide, it materially increases the Brinell hardness and wear resistance of the heavier sections of the same casting. In other words, apart from the effect of copper on the breakdown of free carbide or chill, it hardens the pearlitic matrix and therefore promotes greater uniformity of hardness from section to section. The refinement of the graphite and the increase in the uniformity of the structure usually result in an increase in machinability in spite of the higher hardness. This is taken advantage of in such applications as pump castings, machine-tool castings, sheaves, pulleys, etc., where an increase in the wear resistance and density is desirable in addition to what might be termed "free machining." A similar application of this same effect is found in the copper-molybdenum or copper-vanadium combinations in which a high hardness and excellent wear resistance are combined with good machinability. Castings of this type are usually machinable with a Brinell hardness of over 300.

(*To be continued.*)

# Iron and Steel Scrap Control

## REVISED PRICE SCHEDULES

The Minister of Supply has made the Iron and Steel (No. 7) (Scrap) Order, 1940, to take effect as from March 5. It fixes new prices for iron and steel scrap and supersedes the Control of Iron and Steel (No. 5) (Scrap) Order, 1939.

The effect of the Order is to increase the main range of maximum prices of iron and steel scrap by from 5s. to 10s. per ton. Adjustments to meet changing conditions have led to larger increases in a few cases. In substance the scope of the Order remains unchanged, but there have been certain additions to the specifications of the material covered by the maximum price provisions.

The Direction (No. 1) under the Order issued therewith repeats the provisions of the similar Direction under the previous Order, exempting the sale and purchase of scrap from the requirement of licence, except for certain special types.

Table I shows the new maximum prices per ton for scrap iron and steel for use for iron and steel foundry castings. The following specifications apply:—

1.—*Short, heavy steel scrap,* consisting exclusively of rails, railway tyres and fishplates in cupola sizes not exceeding 2 ft. in length.

TABLE I.—*Maximum Prices per ton for Scrap Iron and Steel for Use for Iron and Steel Foundry Castings.*

| For Consumers in | Specification No. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. |
| Scotland | 75 9 | 73 3 | — | 93 0 | 88 0 | 93 0 | 76 0 | 71 0 | 56 6 | 49 0 |
| Northumberland, Durham and Middlesbrough | 76 0 | 73 6 | — | 90 6 | 88 0 | 88 0 | 78 3 | 73 3 | 63 9 | 52 0 |
| Cumberland | 75 9 | 73 3 | — | 87 3 | 82 3 | 82 3 | 73 6 | 68 6 | 61 3 | 54 0 |
| Westmorland, Lancs and Wirral Penin. | 73 3 | 70 9 | — | 83 3 | 78 3 | 78 3 | 71 0 | 66 0 | 57 6 | 47 0 |
| West and North Ridings of Yorkshire (excluding Middlesbrough) | 78 3 | 75 9 | 117 3 | 85 9 | 80 9 | 80 9 | 76 0 | 71 0 | 61 3 | 49 6 |
| East Riding of Yorkshire | 78 3 | 75 9 | — | 89 3 | 87 0 | 88 0 | 76 0 | 71 0 | 61 3 | 49 6 |
| Derby and Nottingham | 78 3 | 75 9 | 117 3 | 88 3 | 85 9 | 85 9 | 78 0 | 73 0 | 61 3 | 49 6 |
| Lincoln and Cambridge | 78 3 | 75 9 | — | 85 9 | 83 3 | 85 9 | 76 0 | 71 0 | 62 9 | 51 0 |
| Cheshire (excluding Wirral Peninsula) | 71 0 | 68 6 | — | 85 3 | 80 3 | 80 3 | 70 6 | 66 0 | 56 0 | 52 0 |
| Anglesey, Caernarvon, Denbigh, Flint, Merioneth, Montgomery and Radnor | 71 0 | 68 6 | — | 83 3 | 78 3 | 78 3 | 68 6 | 63 9 | 61 3 | 52 0 |
| Salop, Staffs, Worcester and Warwick | 71 0 | 68 6 | 110 0 | 91 0 | 86 3 | 86 3 | 79 0 | 74 0 | 63 9 | 45 3 |
| Leics, Northants, Huntingdon and Rutland | 75 9 | 73 3 | — | 88 6 | 83 9 | 86 0 | 74 0 | 71 0 | 58 9 | 50 0 |
| Norfolk | 75 9 | 73 3 | — | 85 9 | 80 9 | 85 9 | 71 0 | 66 3 | 56 3 | 50 0 |
| Suffolk | 75 9 | 73 3 | — | 86 9 | 81 9 | 86 9 | 73 3 | 68 6 | 58 6 | 50 0 |
| Cardigan, Brecknock, Carmarthen, Pembroke, Glamorgan, Monmouth, Hereford and Gloucester | 78 3 | 75 9 | — | 85 9 | 80 9 | 85 9 | 77 0 | 72 3 | 61 3 | 53 0 |
| Somerset, Dorset, Wilts, Hampshire and Sussex | 71 0 | 68 6 | — | 85 9 | 80 9 | 80 9 | 71 0 | 66 3 | 56 3 | 45 3 |
| Oxford, Berks and Beds | 71 0 | 68 6 | — | 88 0 | 83 3 | 83 3 | 76 0 | 71 0 | 61 0 | 45 3 |
| Essex and Kent | 71 0 | 68 6 | — | 85 9 | 81 0 | 81 0 | 72 3 | 67 3 | 51 6 | 45 3 |
| County of London | 71 0 | 68 6 | — | 81 0 | 76 3 | 76 3 | 69 0 | 64 0 | 51 6 | 45 3 |
| Middlesex, Surrey, Hertford and Bucks | 75 9 | 73 3 | — | 83 6 | 78 9 | 78 9 | 71 6 | 66 6 | 51 6 | 45 3 |
| Cornwall and Devon | 71 0 | 68 6 | — | 76 0 | 71 0 | — | 61 3 | 56 6 | 46 6 | — |
| Northern Ireland | — | — | — | 85 6 | 80 9 | — | 68 6 | 63 6 | 53 6 | — |

2.—*Short, heavy steel scrap,* consisting of shearings, bar ends and constructional scrap not less than ¼ in. thick, in cupola sizes not exceeding 2 ft. in length.

3.—*Hematite ingot-mould scrap,* in cupola sizes.

4.—*Heavy machinery (including textile machinery) cast-iron scrap,* in cupola sizes.

5.—*Ordinary heavy cast-iron scrap,* not less than ¼ in. thick, in cupola sizes.

6.—*Cast-iron railway chairs.*

7.—*Medium cast-iron scrap,* consisting of gas stove plate, wringers and similar, in cupola sizes.

8.—*Light cast-iron scrap,* in cupola sizes.

9.—*Burnt cast-iron scrap and firebars,* in cupola sizes.

10.—*Heavy shovellable steel turnings,* free from alloys and non-ferrous metals.

### General Provisions

The scheduled prices are based upon the scrap being clean and to specification in accordance with the custom of the trade; otherwise a proper allowance must be made. They are for deliveries free to consumers' works; the prices where other forms of delivery are adopted must be in proper relation thereto.

For sales c.i.f. ports or wharves on the East Coast of the United Kingdom the maximum prices shall be:—

(1) For ports or wharves on the East Coast of England—the scheduled prices for consumers in Northumberland, Durham and Middlesbrough.

(2) For ports or wharves on the East Coast of Scotland—the scheduled prices for consumers in Northumberland, Durham and Middlesbrough, plus 1s. per ton.

For cast-iron scrap, specifications 4, 5, 6, 7, 8, arising in Scotland, for consumers in Scotland the maximum prices shall be:—

(*a*) For deliveries free on rail or free on lorry at loading point, the scheduled prices for consumers in Scotland, less

(i) 3s. per ton and less,

(ii) the excess (if any) of the actual cost of transport to consumers' works over 6s. per ton.

(*b*) For deliveries free to consumers' works, the scheduled prices for consumers in Scotland, less 3s. per ton, but plus

(i) the actual cost of transport to consumers' works, or

(ii) 6s. per ton,

whichever shall be the less.

Where delivery of scrap of any one specification under an order of 50 tons and upwards is tendered at the rate of not less than 50 tons per three months, the maximum prices shall be increased by 2s. 6d. per ton.

### Refined Pig-iron Making

Maximum prices for scrap for use in the manufacture of refined pig-iron are shown in Table II. Where delivery of scrap of any one specification under an order of 50 tons and upwards is tendered at the rate of not less than 50 tons per three months the maximum prices may be increased by 2s. 6d. per ton.

Prices higher than the maxima laid down for the various qualities of scrap are not permissible except under authorisation of the Minister of Supply, which will only be given if the Minister is satisfied that by reason of transport or other difficulties reasonably adequate supplies are not obtainable within the usual areas of supply. The maximum prices may, however, be increased by 2½ per cent. in the case of sales by *bona fide* scrap iron and steel merchants carrying on business as such on September 22, 1939.

TABLE II.—*Maximum Prices Per Ton for Scrap Iron and Steel for Use in the Manufacture of Refined Pig-Iron.*

| Specifications. | For Consumers in | | | |
|---|---|---|---|---|
| | Northumberland, Durham and Yorkshire. | Cumberland and North Lancashire. | North Staffs and Salop. | South Staffs and Worcester. |
| 1.—Short heavy steel scrap, not less than ¼ in. thick | 73/6 | 73/3 | 68/6 | 68/6 |
| 2.—Hematite ingot-mould scrap, in cupola sizes | 110/0 | — | 110/0 | — |
| 3.—Heavy machinery (including textile machinery) cast-iron scrap, in cupola sizes | 90/6 | 87/3 | 91/0 | 91/0 |
| 4.—Ordinary heavy cast-iron scrap, in cupola sizes | 88/0 | 82/3 | 86/3 | 86/3 |
| 5.—Medium cast-iron scrap, consisting of gas stove plate, wringers and similar, in cupola sizes | 78/3 | 73/6 | — | — |
| 6.—Light cast-iron scrap, including bedstead cast iron, in cupola sizes | 73/3 | — | — | 74/0 |
| 7.—Hydraulically - compressed new steel and heavy faggotted steel | 70/0 | — | — | 60/0 |
| 8.—Heavy shovellable steel turnings | 50/6 | 51/6 | 46/9 | 42/9 |
| 9.—Wire rope, in coils or cut lengths, to works' specification | 65/0 | — | — | — |
| 10.—Cast-iron borings | 45/0 | 50/0 | 40/0 | 42/6 |
| 11.—Cast-iron borings, not exceeding 0.5 per cent. P. | 50/0 | — | — | — |
| 12.—Burnt cast-iron scrap and firebars, in handy pieces | 63/9 | 61/3 | 63/9 | 63/9 |
| 13.—Compressed destructor scrap | 46/9 | 41/9 | 44/3 | 39/3 |

## Contracts Open

**Cannock,** March 15—Castings, tools, etc., for 12 months ending March 31, 1941, for the Urban District Council. Mr. Edwin Lomax, engineer, Council House, "The Green," Cannock, Staffs.

**Dewsbury,** March 16—Cast-iron pipes and specials, steel tubes, puddled iron tubes and fittings for 12 months ending March 31, 1941, for the Gas Department. The Gas Manager, Gas Works, Savile Town, Dewsbury.

**Haslingden,** March 11—Iron castings, etc., for 12 months ending March 31, 1941, for the Town Council. Mr. R. Taylor, borough surveyor, Municipal Offices, Haslingden.

**Leeds,** March 11—Iron castings, etc., for 12 months ending March 31, 1941, for the Waterworks Committee. The Waterworks Engineer, Civic Hall, Leeds, 1.

**Manchester,** March 12—Cable, bell wire, steel and iron wire, galvanised steel cable, tools, fishplates, nuts, bolts, chains, iron and steel forgings, iron castings, etc., for the Transport Committee of the Corporation. The General Manager, Corporation Transport Department, 55, Piccadilly, Manchester, 1.

### Emergency Repairs by Welding

A joint informal meeting of the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers has been arranged for Monday next, March 11, to be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, at 6 p.m., when Dr. S. F. Dorey, M.I.Mech.E., will open a discussion on "Emergency Repairs to Plant with Special Reference to Welding." Members are invited to take part in the discussion.

# Fatigue Failure of Locomotive Tyres

## EFFECT OF BORING PRACTICE ON RESISTANCE

In a Paper contributed to the Proceedings of the Institution of Mechanical Engineers, MR. C. W. NEWBERRY, B.Sc., deals with "Locomotive Tyre Failures," and he draws a number of conclusions which may have repercussions on the steel-foundry industry. These conclusions are appended.

### Fatigue the Principal Cause

One of the first and most striking features of the investigation has been the preponderance of defects due to fatigue, the proportion of fatigue failures being nearly 80 per cent. of the total. The other failures were mostly due to defective material.

According to calculations based on the position and shape of the majority of fatigue flaws in tyres, it is thought that, in addition to the normal wheel impacts on the rail, flange impacts, especially those on the back of the flange, are an important contributory feature in the production of fatiguing stresses. This deduction is supported by some of the evidence concerning the distribution of failures, particularly the marked susceptibility to failure of leading coupled wheels which are not preceded by a bogie.

Although defective material, especially the presence of segregation or non-metallic matter, may hasten fatigue failure, fatigue flaws frequently develop in tyres that appear to be of satisfactory material. The main features influencing the growth of the defects are as follow.

### Increasing Fatigue Resistance

The fatigue strength of the tyre bore is always below the intrinsic strength of the tyre steel, owing to the effects of machining and corrosion in producing stress concentrations at surface irregularities. Tests made on specimens of tyres bored under various conditions showed that the fatigue resistance achieved by standard shop practice could be increased by about 90 per cent. if the boring were done with a molybdenum-titanium carbide tool. This fact alone gave promise of a simple means of raising the fatigue strength of tyres above the range of the fluctuating stresses encountered in service.

Local stress concentrations due to stud and rivet fastenings of tyres were found to have a marked influence on the development of fatigue flaws. In several instances the failure was directly attributed to this cause in conjunction with a low fatigue resistance due to the condition of the tyre bore.

Irregularities in the support of the tyre, owing to out-of-roundness of the wheel rim, have frequently been noticed as contributory factors in fatigue failure. One of the underlying causes of the out-of-roundness has been the variation in stiffness and heat capacity of the rim caused by the cast-in type of balance weight.

In addition to the feature noted above concerning the susceptibility to fatigue of wheels which sustain the major impacts, it is important to notice the relative proportion of driving to other coupled wheels involved in fatigue failure. The probability of fatigue flaws developing in tyres is almost twice as great in the case of driving wheels as in the case of other coupled wheels. It also appears, again bearing wheel impacts in mind, that the total unsprung mass of an axle assembly should be kept as small as possible because of its effect on the tyre, as well as because of the well-known effects on the track.

There is a very definite relationship between the size of the wheel and the occurrence of fatigue failure. As demonstrated in the Paper, the larger tyres sustain fatigue flaws at a greater mean thickness than do smaller tyres, which means that their liability to fatigue is greater. In this connection, however, a reminder of a warning given earlier may not be out of place. Increase in the size of the wheel affects so many other factors which are interdependent with the incidence of fatigue failure that it must not be assumed that mere increase in diameter will weaken a tyre against fatigue. Indirectly it will, through the increased arc of contact at the rail and the consequent increase of flange forces, through the increased mass, and through the reduced rigidity. It is these factors which must be borne in mind in designing a wheel that shall help to give immunity from fatigue failure.

### Desirable Design Features

Emerging from the above, the following features of design which appear to bear on fatigue resistance may be summarised.

(1) An insistence should be made on suitable tyre boring, and with this may be coupled the need for a smooth finish to the wheel rim, to prevent loss of interference fit.

(2) The wheel rim should afford a sufficient and uniform support for the tyre, a condition which requires a deep rim section, and which is assisted by a lead balance-weight cast separately.

(3) The tyre fastenings should be such that they cause no avoidable concentration of the tensile stress at the tyre bore, either directly, or indirectly by increased transverse compression.

(4) The unsprung weight of a wheel and axle assembly should be kept as small as possible, and the wheel arrangements designed to minimise tread and flange impacts on the coupled wheels.

(5) As far as is consistent with speed requirements, the wheel diameter should be kept small.

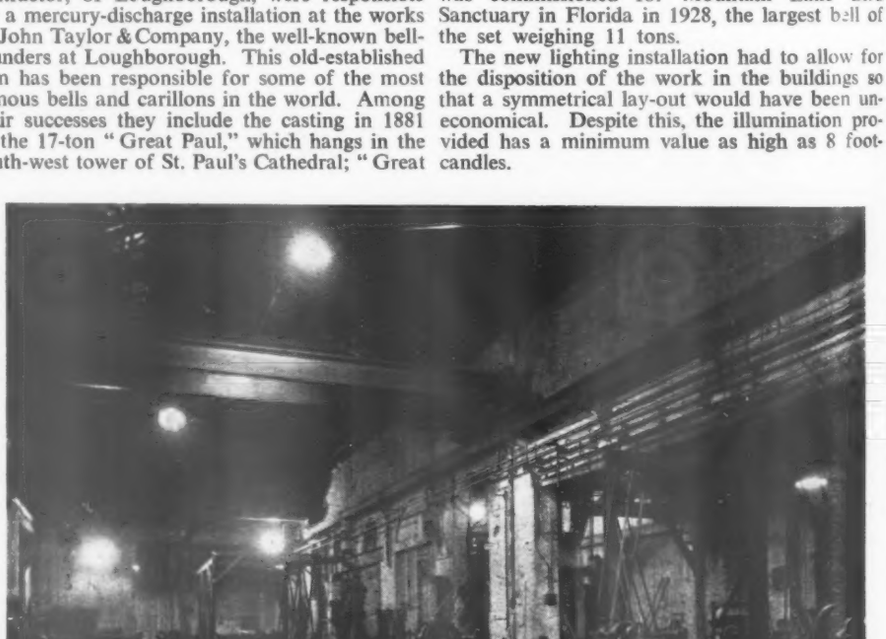
(6) The question of wheel impacts involves the track as well as the locomotive, and there may be a possibility of reducing check rail impacts on tyre flanges by slight modifications to rail design.

In conclusion, it is of interest to note the continued decrease in fatigue failures that has taken place during the progress of the investigation (falling from 21 in 1934 to 7 in 1937). It is particularly significant that, so far, no fatigue failure has been known to occur on any tyre that has been bored with a carbide tool, nor has there been any failure of a tyre associated with the Gibson ring fastening or the modified wheel rim with the balance-weight cast separately. It is confidently expected that the fatigue strength of the wheel assembly has now been raised sufficiently to make fatigue flaws in locomotive tyres a very rare occurrence, if not a thing of the past.

# Lighting in a Bellfoundry

A short time before the outbreak of war Metropolitan-Vickers illuminating engineers, in conjunction with Mr. J. H. Hickling, electrical contractor, of Loughborough, were responsible for a mercury-discharge installation at the works of John Taylor & Company, the well-known bellfounders at Loughborough. This old-established firm has been responsible for some of the most famous bells and carillons in the world. Among their successes they include the casting in 1881 of the 17-ton "Great Paul," which hangs in the south-west tower of St. Paul's Cathedral; "Great Peter" (10½ tons), for York Minster, cast in 1927; and "Little John" (10½ tons), for Nottingham, cast in 1928. A carillon of 72 bells was commissioned for Mountain Lake Bird Sanctuary in Florida in 1928, the largest bell of the set weighing 11 tons.

The new lighting installation had to allow for the disposition of the work in the buildings so that a symmetrical lay-out would have been uneconomical. Despite this, the illumination provided has a minimum value as high as 8 foot-candles.



METROVICK MERCURY-DISCHARGE LIGHTING INSTALLATION IN THE BELLFOUNDRY OF JOHN TAYLOR & COMPANY, LOUGHBOROUGH. A MINIMUM ILLUMINATION OF 8 FT.-CANDLES IS PROVIDED.

# Cast Iron for Modern Engineering Applications

By T. TYRIE (Superintendent, B.C.I.R.A. Scottish Laboratories)

(*Continued from page* 170.)

## MECHANICAL PROPERTIES

Brief reference must be made to the mechanical properties of cast iron which are largely conditioned by the structure, distribution, size and form of the graphite flakes, which latter may be regarded as discontinuities in the structure, giving rise to stress concentrations.

### Hardness and Machinability

Hardness may be expressed in several ways, but as a rule it is taken in accordance with B.S. Specification 240/1926, and recorded as the Brinell hardness number. For exceptionally hard surfaces the diamond hardness may be taken or a rebound type of instrument used. Experience shows that there is no direct relationship between hardness and machinability or between hardness and wear with cast iron, unless the relationship applies to irons of similar structure. Similarly, there is not the definite relationship existing between the hardness and strength of cast iron that there is with steel and many other alloys, but in grey iron of the same type an increased Brinell number generally implies higher mechanical properties and wear resistance.

As in all cast alloys, the hardness of cast iron tends to be higher in thin than in thick sections, and higher at the edge than at the middle of heavy sections. In cast iron this effect tends to be greater than in other cast metals, because superimposed upon the effect produced by rate of cooling on the grain size is the effect produced by cooling conditions on the combined carbon. Much of the work done in developing irons of high strength has aimed at minimising this sensitivity to wall thickness, and most modern high-duty cast irons of suitably controlled composition need not show variations in this respect appreciably greater than those of other metals. The values for Brinell hardness to be expected from castings of various structural compositions are shown in Table III,* that for the nitrided cast iron having been derived from measurements made with a diamond indenter machine.

In brief, it may be said that ordinary machining of cast iron is governed by the hardness and toughness of the matrix, the extent and distribution of hard constituents, such as phosphide and carbide, and the extent and distribution of the graphite; and the production of harder and tougher irons must be expected to result in lower machining speeds.

### Tensile Strength

Grey cast iron has no appreciable elongation or reduction in area under tensile loading, and, like all other static properties, the tensile strength increases as the size of the bar tested diminishes, as long as the metal remains grey. Since tensile strength is a standard test for cast iron upon which the relative differentiation between ordinary and high-duty cast iron is made, it is interesting to see the results obtained in commercial practice for a list of materials covering the range dealt with in the course of the present Paper, and Table IV has been compiled accordingly from data contained in Tables II to XXII† of the First Report of the Research Committee on High-Duty Cast Irons for General Engineering Purposes. It should be clearly understood that the test results embodied therein are not laboratory figures, that is, figures arising from materials made under laboratory conditions, but actual test results obtained on materials supplied by founders from ordinary commercial production.

* Proc. Inst. of Mech. Eng., vol. 140 (1938), pp. 163-256.
† *Loc. cit.*

### Transverse Strength and Deflection

Transverse strength is another standard test for cast iron, and one in many cases specified when no corresponding tensile test is required. Generally it is determined on a standard round bar of dimensions in relation to the thickness of the casting it represents, and yields the transverse load and deflection at fracture. The results are expressed in pounds load on the standard bar, tested on the standard centres, but may be converted by the usual beam formula into a rupture stress expressed in tons per sq. in.

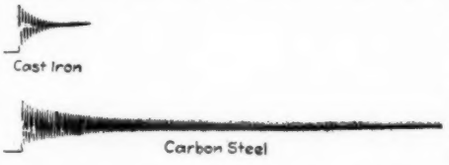



FIG. 13.—CURVES TAKEN WITH FOEPPL-PERTZ DAMPING TESTER INDICATING DIFFERENCE BETWEEN DAMPING CAPACITY OF CAST IRON AND CARBON STEEL (POHL).

The deflection under transverse loading is measured in inches on the standard span, and is used as an index of ductility or toughness instead of the elongation in tension.

In general, the deflection increases with strength or ductility. It is made up of two components, that part remaining on removal of the load, called plastic deflection or permanent set, and the part recovered on removal of the load, called elastic deflection, the curve of the latter, that is, load plotted against elastic deflection, approximating to a straight line. From the transverse test also may be calculated the elastic modulus of cast iron, making use of the total deflection at full load or at some arbitrary fraction of the load, but such results do not represent the true elasticity and more accurate figures are obtained by the "set and deflection" method of transverse testing, where the values of the elastic modulus E are calculated on the beam formula, using for D the figures for elastic deflection referred to above. The value of the modulus of elasticity for grey cast iron varies from about 9 to 18 millions of pounds per sq. in., but for special irons, values of $30 \times 10^{-6}$ lbs. per sq. in. have been reached. Typical values are given in Table IV. The variation in results follows much the same lines as the tensile strength, and depends largely upon the distribution, form and size of the graphite.

### Impact Strength

No standard impact test for cast iron has yet been recognised, but many empirical forms are in use. The ordinary Izod test gives very low results and does not differentiate adequately between different irons. Repeated impact tests give indications of closer discrimination between materials than is possible with the tensile or transverse test, but the time absorbed in such repeated impact tests mitigates against their general adoption, and more recently the B.C.I.R.A. has developed a single-blow impact test on a 0.798-in. unnotched round bar tested in an Izod machine having a suitable vice, which would appear to fill the gap remarkably well.

Related to this property is notch sensitivity. Owing to the fact that the presence of graphite gives rise already to stress concentrations when cast iron is loaded, the material is comparatively less sensitive to the effect of additional notching. This applies to impact, fatigue and other tests and conditions, and in simpler language may be transcribed as meaning that cast iron is less susceptible than other metals to the type of failure arising from stress concentrations at changes of section, re-entrant angles, screw threads, machining marks, drilled oil-ways, etc.

### Damping Capacity

The introduction of high-duty cast irons has undoubtedly introduced the term "damping capacity" into the vocabulary of the foundrymen, since seldom before was the property thus referred to considered in relation to cast iron. This property may be expressed as the capacity of a material to dissipate vibrational energy, and is a property connected with notch sensitivity, since materials of high damping capacity have a low notch sensitivity. Cast iron, as would be expected from its low notch sensitivity, has a very high damping capacity. When materials of high damping capacity are alternately stressed, the vibrations die away more rapidly than in the case of low damping capacity materials.

In many applications, engineering materials are not normally over-stressed, except that they are liable to experience undesired vibrations, and the higher the damping capacity of the material the less likely are these vibrations to attain magnitudes which can cause seriously high stress. The relative damping capacities of cast iron and carbon steel may be visualised from the curves taken with the Foeppl-Pertz damping capacity tester, and typical graphical results are illustrated in Fig. 13,* which gives an indication of the reason for the successful application of cast iron to the manufacture of cast crankshafts for internal-combustion engines.

### Wear Resistance

Cast iron, either grey or white, finds universal use for resistance to wear. A relationship is often sought between wear resistance and hardness, but this is largely non-existent, and wear resistance must be regarded in relation to the service conditions. An all-pearlitic iron with medium-sized, evenly-distributed graphite flakes is found to be the best material for most purposes, and where otherwise acceptable, small dispersed areas of phosphide or carbide will improve wear resistance. For applications such as chilled rolls, crushing machinery and grinding equipment, it appears that the white irons which best resist wear are those with the greatest amount of carbide in the structure. For abrasive wear, and for many conditions of corrosive wear, the austenitic irons give excellent service.

### Heat Resistance

Cast iron differs from most materials, from the heat-resisting point of view, in that it not only tends to scale externally, but is also liable to growth. This growth is due to internal carbide break-down, followed by internal oxidation, the oxide formed being greater in volume than the metal oxidised and the stress thus set up produces cracking. For certain types of usage and where machinability is not essential and brittleness not a handicap, white cast iron free from graphite may be used. Additions of chromium make the carbide still more stable and in the extreme case of 30 per cent. chromium cast iron a material is produced which is tough, strong, machinable and remarkably resistant to growth and scale. Typical test results for the mechanical properties of this class of iron are included in Table IV.

* W. M. Pohl, "Vibrations of Structures," "Product Engineering," vol. 4, No. 3, March, 1933, p. 91.

For heat resistance at temperatures below the critical point, that is, 700 to 750 deg. C., low-silicon grey irons of close grained structure are possible. Irons of the "Silal" type containing 5 to 6 per cent. silicon have good resistance to scaling and growth, and may be used at temperatures up to 900 deg. C., but they are extremely brittle. The austenitic irons "Nicrosilal" and "Ni-resist" are much better in this respect and may be used up to temperatures approaching their melting point, but they are not recommended for conditions where appreciable quantities of sulphurous gases are present, since these promote scaling.

An aluminium-chromium cast iron has been developed under the name of "Cralfer" by the B.C.I.R.A. in conjunction with British and Dominions Feralloy, Limited, and covered by British Patent No. 489,936. This alloy cast iron marks a distinct advance on previous metals, in that it embodies the excellent scale- and growth-resisting properties of the high-silicon irons without the brittleness which accompanies that type of material. "Cralfer" is certainly somewhat more brittle than grey cast iron in the cold, though the impact value is good, but it is remarkably strong at elevated temperatures. Typical properties for this alloy cast iron are given in Table V.

TABLE III.—*Brinell Hardness Values from Castings of Various Structural Composition.*

| Structural composition. | Brinell No. |
|---|---|
| Very soft ferritic castings .. | 110—140 |
| Soft grey iron .. .. .. | 140—180 |
| Pearlitic iron .. .. .. | 180—240 |
| Pearlitic alloy iron of low alloy content .. .. .. | 210—300 |
| Sorbitic irons .. .. .. | 280—350 |
| Martensitic irons .. .. .. | 350—450 |
| White iron, unalloyed .. .. | 280—500* |
| White iron, alloyed .. .. | 450—500 |
| Martensitic white iron .. .. | 550—700 |
| Nitrided iron .. .. .. | 900—1,000† |

* The higher the total carbon the greater the hardness.
† On surface only. Derived from measurements with a diamond indenter machine.

TABLE V.—*Properties of "Cralfer" Heat-Resisting Cast Iron* (T.C, 3.0; Si, 1.0; Mn, 0.6; Cr, 0.75, and Al, 7.25 per cent.).

| | |
|---|---|
| *Mechanical Properties—* | |
| Tensile strength at room temperature .. .. .. | 15 to 19 tons per sq. in. |
| Transverse breaking load (1.2-in. dia., 18-in. span).. .. | 1,850 to 2,530 lbs. |
| Transverse rupture stress .. | 22 to 30 tons per sq. in. |
| Deflection in transverse .. | 0.10 to 0.15 in. |
| Brinell hardness No. .. .. | 290 to 340 |
| Repeated impact test .. .. | 1,000 to 1,500 blows to fracture. |
| Izod impact test (0.798-in. dia. bar, unnotched) .. .. | 7 ft.-lbs. |
| *Physical Properties—* | |
| Melting point .. .. .. | 1,245 deg. C. |
| Specific gravity.. .. .. | 6.77 |
| Weight in lbs. per cub. in. .. | 0.246 |
| Co-efficient of expansion— | |
| Room temperature to 450 deg. C. | $1.34 \times 10^{-5}$ |
| 450 to 1,000 deg. C... .. | $1.58 \times 10^{-5}$ |
| Thermal conductivity— | |
| 44 to 123 deg. C. .. .. | 0.080 |
| 333 to 527 deg. C. .. .. | 0.072 |
| *Heat-Resisting Properties—* | |
| Scaling tests at 950 deg. C. in pre-heated products of combustion of town gas. Gain in weight given in grammes per sq. cm. per 100 hours. | |
| "Cralfer" .. .. .. | 0.026 |
| "Silal" .. .. .. | 0.067 |
| Grey cast iron .. .. | 0.195 |
| Growth tests at 950 deg. C. Seven heating periods: six of three hours and one of 20 hours. Growth given as percentage increase in volume. | |
| "Cralfer" .. .. .. | 1.3 |
| "Silal" .. .. .. | 1.5 |
| Grey cast iron .. .. | 24.0 |

## Corrosion Resistance

The corrosion resistance of cast iron, like wear and heat resistance, can only be considered properly in relation to the conditions of service, since irons suitable in one application may not prove so serviceable in others. So far as cast iron of normal composition is concerned, sound, dense castings are more important than minor changes in composition, and in most cases the casting skin is more resistant to attack than a machined surface. Under such conditions, cast iron is possibly as good as, if not better than, other unalloyed ferrous materials in its resistance to mild corrosive agents. Several cast irons have been developed for special corrosion-resisting purposes; the high-silicon group, containing up to 15 per cent. silicon, has long been valued for use in chemical plant.

High-chromium irons containing up to 30 per cent. chromium offer a useful combination of resistance to corrosion, heat and erosion, whilst the austenitic irons, such as "Nicrosilal" and "Ni-resist," which have strengths of 13 to 16 tons per sq. in. in tensile, and Brinell hardness numbers of 140 to 160, with greater resistance to impact than grey cast iron, show corrosion resistance of the order of 3 to 600 times the value of grey pearlitic iron, depending upon the medium, which combination of properties renders them extremely serviceable under conditions both corrosive and erosive.

## PHYSICAL PROPERTIES

Brief reference may be made to the physical properties of high-duty cast iron. So far as mechanical engineering is concerned, the most important physical property is the thermal expansion. For grey pearlitic cast irons this is in the order of $1.4 \times 10^{-5}$ at temperatures between 20 deg. C. and the critical temperature of the pearlite change, though frequently a value close to $1.1 \times 10^{-5}$ is found up to the Curie point at 200 to 300 deg. C., at which temperature structural changes occur in any free carbides present, a point of special importance in any material which may be used at moderate temperatures, as for example, piston-ring metal. Change in chemical composition does not produce any appreciable change in thermal expansion with grey cast iron, but change in structural composition produces a more pronounced alteration in the thermal expansion; thus, the austenitic cast irons have a higher value of the order of $1.8 \times 10^{-5}$.

TABLE IV.—*Properties of High-Duty Cast Irons.*

*Mechanical Tests—*

| No. | Transverse rupture stress. Tons per sq. in. | Deflection on 18-in. span. In. | Elastic modulus. Lbs. per sq. in. $\times 10^{-6}$ | Ultimate tensile stress. Tons per sq. in. | Brinell hardness number. | Single impact test. Ft.-lbs. | Repeated impact test. No. of blows to fracture. |
|---|---|---|---|---|---|---|---|
| 1 | 28.6 | 0.19 | 18.9 | 18.0 | 241 | 8.5 | 647 |
| 2 | 36.8 | 0.30 | 20.0 | 19.2 | 229 | — | — |
| 3* | 34.3 | 0.13 | 20.6 | 17.9 | 259 | 8.3 | 665 |
| 4 | 34.2 | 0.37 | 18.4 | 16.6 | 185 | — | — |
| 5† | 40.2 | 0.28 | 16.6 | 23.7 | 295 | — | — |
| 6 | 39.5 | 0.33 | 21.0 | 22.5 | 207 | 9.7 | 9,000 |
| 7 | 34.0 | 0.23 | 17.0 | 22.4 | 256 | 13.0 | 6,619 |
| 8 | 41.3 | 0.26 | 19.3 | 23.2 | 268 | 17.5 | 24,900 |
| 9* | 31.6 | 0.13 | 18.6 | 19.4 | 241 | 9.2 | 2,248 |
| 10* | 33.1 | 0.13 | 18.1 | 18.0 | 268 | 8.4 | 1,830 |
| 11* | 34.7 | 0.17 | 12.5 | 18.1 | 234 | 11.9 | 5,930 |
| 12 | 29.5 | 0.16 | 19.6 | 18.3 | 290 | — | — |
| 13 | 32.3 | 0.19 | — | 20.6 | 260 | — | — |
| 14 | 35.3 | 0.25 | 17.5 | 24.2 | 293 | 13.7 | 150,929 |
| 15 | 34.3 | 0.23 | 19.9 | 22.0 | 231 | 12.1 | 4,995 |
| 16 | 25.0 | 0.29 | 14.5 | 13.3 | 157 | 21.5 | 1,600 |
| 17 | 26.9 | 0.10 | 26.6 | — | 285 | — | 152,000† |
| 18 | 32.3 | 0.11 | 33.2 | 28.0 | 331 | 13.1 | 152,000† |

* 0.875 in. diameter bar tested on 12-in. centres.
† Similar to No. 4, but heat-treated. Oil quenched 875 deg. C., tempered 500 deg. C.
*Note.*—Nos. 1 to 4 and 9 to 12 fulfil B.S. Specification No. 786 (2); Nos. 5 to 8 and 13 to 15 fulfil B.S. Specification No. 786 (3), and Nos. 16 to 18 are special alloy irons not subject to B.S. Specifications.

*Chemical Analyses, Per Cent.—*

| No. | T.C. | C.C. | Gr. C. | Si. | S. | P. | Mn. | Ni. | Cr. | Cu. | Mo. | Type of iron. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.06 | 0.81 | 2.25 | 1.32 | 0.133 | 0.76 | 0.57 | — | Tr. | — | — | Cupola melt, ordinary. |
| 2 | 2.89 | 0.92 | 1.97 | 1.97 | 0.115 | 0.24 | 0.67 | — | — | — | — | " " low-carbon. |
| 3 | 2.65 | 0.91 | 1.74 | 2.39 | 0.079 | 0.23 | 1.49 | — | 0.07 | 0.06 | — | " " " " |
| 4 | 3.16 | 0.95 | 2.21 | 0.93 | 0.093 | 0.15 | 0.78 | — | — | — | — | " " hot-mould. |
| 5 | 3.10 | 0.98 | 2.12 | 0.97 | 0.092 | 0.14 | 0.77 | — | — | — | — | " " " " |
| 6 | 2.81 | — | — | 1.20 | 0.100 | 0.20 | 0.60 | — | — | — | — | " " Meehanite. |
| 7 | 3.19 | 0.99 | 2.20 | 1.36 | 0.079 | 0.32 | 0.85 | 1.43 | 0.09 | Tr. | — | " " Ni-Tensyl. |
| 8 | 2.89 | 1.09 | 1.77 | 1.51 | 0.084 | 0.08 | 1.23 | 1.75 | Tr. | Tr. | — | " " " " |
| 9 | 3.18 | 0.87 | 2.31 | 2.06 | 0.103 | 0.17 | 0.92 | — | 0.21 | 0.21 | — | " " low alloy. |
| 10 | 2.72 | 0.86 | 1.86 | 2.26 | 0.094 | 0.28 | 1.13 | — | 0.14 | 2.12 | — | " " alloy low T.C. |
| 11 | 3.20 | 1.03 | 2.17 | 1.26 | 0.125 | 0.46 | 0.89 | 1.52 | — | 0.36 | — | " " alloyed. |
| 12 | 3.21 | 1.28 | 1.93 | 1.26 | 0.109 | 0.06 | 0.49 | 1.31 | 0.52 | — | — | " " " |
| 13 | 2.91 | 0.89 | 2.02 | 1.50 | 0.073 | 0.16 | 0.90 | 0.16 | 0.12 | 0.16 | 0.81 | Electric melt, alloyed. |
| 14 | 2.79 | 0.93 | 1.86 | 1.24 | 0.034 | 0.03 | 0.79 | 1.65 | — | — | 0.39 | " " " |
| 15 | 3.00 | 0.87 | 2.13 | 1.62 | 0.090 | 0.17 | 0.82 | — | 0.06 | Tr. | 0.63 | " " " |
| 16 | 2.46 | 0.81 | 1.65 | 1.50 | 0.020 | 0.74 | 4.09 | 11.20 | — | — | — | Rotary melt, non-magnetic. |
| 17 | 1.01 | 1.01 | — | 1.80 | 0.028 | 0.01 | 0.46 | 0.19 | 33.53 | 0.10 | — | Electric melt, heat and corrosion resisting. |
| 18 | 1.14 | 1.14 | — | 1.78 | 0.034 | 0.01 | 0.47 | 0.22 | 33.83 | 2.01 | — | |

No. 14 is a synthetic iron made from steel and ferro-alloys.

Thermal conductivity varies between 0.11 and 0.14 C.G.S. units, and is affected by composition and structure. White irons have a lower conductivity than grey irons, and the austenitic grey cast irons are less conductive than ordinary grey cast iron, being in the neighbourhood of 0.07 C.G.S. units. Increasing the amount of graphite increases the conductivity, whilst refining the graphite lowers the thermal conductivity. The electrical resistivity of grey cast iron is of the order of 60 to 100 microhms per cm. cube, and of austenitic cast irons about 150. It increases with rise in carbon and silicon contents and also with increasing graphite. The resistivity decreases as the graphite becomes finer. The magnetic permeability of cast iron is of the greatest interest. For grey cast iron the figure is of the order of 240 gauss, whilst in austenitic

cast irons it is about 1.03 gauss, these irons being virtually non-magnetic, and of the utmost interest to the electrical industry.

In conclusion, due acknowledgment must be given to the work of the Research Committee on High-Duty Cast Iron for General Engineering Castings, established by the Institution of Mechanical Engineers, whose First Report was prepared and presented in December, 1938, from the text of which report extracts have been made and data and illustrations drawn in compiling the present Paper. Also, the author wishes to express his indebtedness to Mr. J. G. Pearce, the Director of the B.C.I.R.A., for permission to make use of other data and illustrations in preparing the Paper, and to a few colleagues for their collaboration and helpful criticism.

## DISCUSSION

Mr. Norman E. Erskine (Branch-President), who presided over the meeting of the Scottish Branch of the Institute of British Foundrymen at which Mr. Tyrie's Paper was presented, described the Paper as a most comprehensive and complete survey of high-duty cast irons, their characteristics and applications. He thought that when the Paper was published it would form a very useful reference on the subject.

Mr. J. M. Primrose said that a Paper of the nature of that submitted, if it was to be of any value to the majority of foundrymen, should be printed and distributed prior to the meeting so that they could read it and be prepared to ask questions, as it was too advanced to assimilate by mere listening.

Mr. H. D. Campbell said he could not agree with Mr. Primrose, as he himself had followed the entire Paper with interest. He was particularly attracted to the last section, which dealt with irons for special service such as heat and corrosion resistance He would have liked to hear more about the heat-resisting materials "Silal," "Nicro-silal" and particularly "Cralfer" iron. He hoped it would be possible for Mr. Tyrie to present another Paper dealing with the properties and preparation of some of these materials.

### Unsuitable Specifications

Mr. W. Montgomery said he thought it necessary and desirable to bring the characteristics and properties of cast iron to the notice of the designer so that he should not call for unsuitable specifications. He (Mr. Montgomery) had recently experienced a good deal of trouble due to the designer specifying a composition characterised by low total carbon, silicon and phosphorus as well as imposing a high pressure test. The casting had varying sections and gave great difficulty in foundry handling. He had found that the composition specified gave rise to a large gas content. If he had been allowed to choose his own composition he would have been able to handle the metal more easily and have made the castings pressure-tight to an enhanced degree. He found that with the material specified by the designer a skin formed on it and was the cause of leakers.

Mr. Tyrie observed that such cases did arise because, apparently, the engineer referred to particulars of some casting which had given good service, but which bore no relation to the casting to be produced, and specified that material. He thought, however, that such cases were in the minority, the average engineer being content to state what he wanted and to leave the founder to exercise his judgment and experience.

### Phosphorus Content and Hardness

Mr. R. S. M. Jeffrey said that, in regard to the first section of the Paper which dealt with the composition of the high-duty irons, and with the fact that the structural composition was the vital factor in securing the high strength and other properties, he was in agreement with the author. In the tables of physical properties, he noted that Mr. Tyrie had given the tensile strength of Ni-Tensyl as 22 to 26 tons per sq. in. against 20 to 25 tons per sq. in. for Meehanite. As a matter of everyday practice, he was making Meehanite without alloy addition which gave over 25 tons per sq. in. in the as-cast condition.

When dealing with the graphitising value of manganese he thought that the author should have referred to the sulphur effect. In so far as heat-treatment was concerned, it was not necessary to use alloys to make high-duty iron susceptible to such treatment. Meehanite was regularly made for heat-treatment without any alloy additions. In considering the Brinell number, the phosphide content must be mentioned. A high-phosphorus material would not give so low a reading as 110.

Mr. Tyrie said he fully appreciated that, so far as Meehanite was concerned, 20 to 25 tons did not represent the maximum that could be obtained; he was aware that higher strengths were being regularly obtained. In regard to the heat-treatment of high-duty irons, he stated that they were more susceptible to heat-treatment and realised that much higher strengths could be obtained than those cited in the Paper. He agreed with Mr. Jeffrey's remarks about the phosphide. The Brinell number would be much higher in a high-phosphorus material than that given. Engineering irons, however, rarely went as high as 0.6 per cent.

### Practical Difficulties

Mr. W. W. Braidwood thought that the foundryman was to-day faced with a very difficult problem. The engineers were specifying high-strength irons, so he had to consider contracts for high-duty castings. He probably could not afford or did not feel inclined to take out a licence to make special material, and he found great difficulty in producing the metal specified. It was a very difficult matter to make high-duty cast iron, and any one starting upon the manufacture of such material must look forward to a great deal of trouble. He had found it possible to meet the high-duty specification by using selected scrap and the addition of certain alloys. If satisfactory steel scrap could be obtained, he had found that he could produce the material satisfactorily. He might perhaps give a report on this at a later date. In regard to "Cralfer" irons, Mr. Braidwood said he had had experience of making this material, and he warned anyone who started to make it that he could anticipate a very large amount of trouble.

### Controlled Methods Essential

Mr. Tyrie agreed that high-duty iron was difficult to make, and one would never get results by indiscriminate working. It was necessary to control every phase of the process.

Mr. A. Campion said he could not agree that there was great difficulty in producing high-duty cast iron; it was quite a simple matter if the job was tackled in the proper manner. In fact, it was an easier matter to produce a metal of 20 tons per sq. in. tensile strength than an iron of 9 to 10 tons. The great difficulties to which reference had been made would only be encountered by people who tried to make the material by back-door instead of open methods. To be successful, certain fundamental factors had to be considered and controlled. Haphazard rule-of-thumb methods of working would never succeed; foundry technique had to be changed and every operation brought under positive control. The old idea of throwing in a bit more of this or a little less of something else would not work.

He wished to refute the statement so often made, and which had been repeated in the Paper, that Meehanite was a very low total carbon iron. Meehanite was not necessarily of low total-carbon content, certainly never of the order of 2.2 to 2.8 per cent., which had been given. The carbon content of Meehanite was adjusted to suit the service required from the casting and in some cases was as high as 3.4 to 3.5 per cent. Meehanite was a material, the properties of which could be consistently guaranteed, and had established itself with the leading engineers and largest consumers on its merits. There were probably more competitors and imitators of Meehanite than of any other type of high-duty iron; but as imitation was considered the sincerest form of flattery, the Meehanite organisation welcomed them all as a tribute to the worth of the metal.

Mr. Tyrie said that he regarded Mr. Campion's remarks as support of what he had said as to the necessity of very careful work in the production of high-duty irons, and the need for very strict control of every phase of the foundry process.

### Impact Strength of High-Duty Irons

Mr. J. E. O. Little drew attention to one point which, he said, Mr. Tyrie might have dealt with in connection with the replacement of steel by high-duty cast iron; that was in regard to the strength. The strength was really greater in the irons than in steel, because with an iron of 25 tons per sq. in. tensile strength the yield point would be in the region of 20 tons per sq. in., against about 12 tons in the case of mild steel. In regard to impact values of materials, it was often stated that, because of its ductility, steel would resist impact more than the cast iron. The high-duty cast irons were not, as many people thought, brittle materials, and one had only to try breaking up some of these materials to discover that fact!

Mr. Tyrie said he fully realised the import of Mr. Little's remarks and was in agreement with him. Some of the high-duty materials were far from being brittle materials in the ordinary sense of the term.

# Radiography of Castings in U.S.A.

Last week we reproduced extracts from an article by Mr. Charles W. Briggs on "Radiographic Development in the Casting Industries," which appeared in "Metals and Alloys." The author's comments on the use of radiography in aluminium and steel foundries are also of interest.

He states that aluminium alloy castings such as those being used in the aircraft industry are being inspected by radiography in large numbers. One inspection service reports several thousand castings being inspected weekly by X-rays.

In the steel casting industry high-pressure high-temperature equipment is receiving the bulk of radiographic inspection, though considerable radiographic inspection is being given to structural castings which must operate in very exacting services. Gamma-ray radiography is being favoured for the above types of inspection. The U.S. Navy has approximately 4,800 milligrammes of radium, split up into 19 capsules, for the inspection of castings of the above types purchased by the Navy. The Radium Chemical Company of New York City has 34 capsules totalling 3,800 milligrammes of radium available for commercial radiography. Several of the more progressive foundries and users of castings have purchased radium and X-ray equipment for non-destructive testing. High-alloy steel castings, such as the heat-resistant and corrosion-resistant cast steels, are frequently inspected by radiography, the X-ray method being favoured due to the relatively light sections.

# De-Enamelling of Vitreous Enamelled Steel and Sheet Iron

By N. L. EVANS, B.Sc., A.I.C.

(*Continued from page* 103.)

The molten caustic soda process is used in Great Britain and gives excellent results. The principal drawback to it is the frequency with which the tanks burn out. Heating is by means of gas or oil burners, and there is a serious risk of getting local overheating of the wall of the tank, resulting in rapid oxidation on the outside, and perforation.

### Use of Electric Immersion Heaters

In order to overcome this, it is now proposed to use electric immersion heaters. A suitable type of heater is manufactured by the British Thomson-Houston Company, and is known as the "Torribar." This type of heater has been used successfully in salt baths for the heat-treatment of aluminium alloys, at temperatures up to 510 deg. C. Whereas a similar plant fitted with external heating elements gave considerable trouble, one with "Torribar" immersion heaters has been in service for two years without any failure of either the tank or the heating elements. This type of plant is manufactured by the Electric Resistance Furnace Company, who have designed a de-enamelling plant (Fig. 5) on similar lines to their heat-treatment plant.

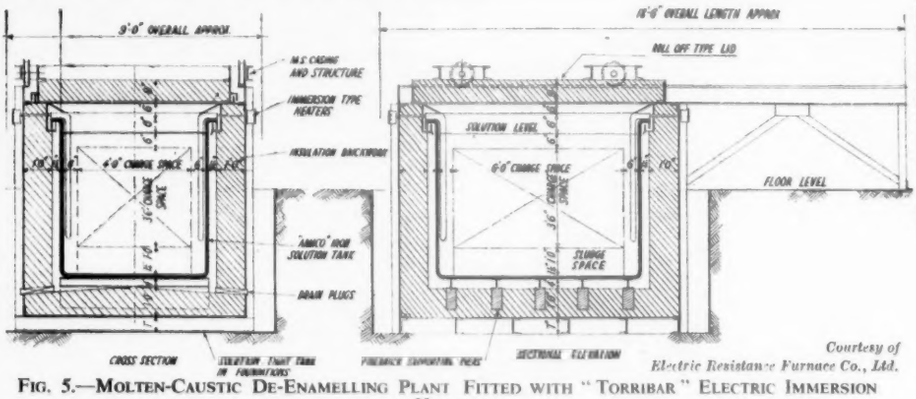
The main difference between the two is that in the heat-treatment plant the "Torribar" elements are shaped to fit down the sides and along the bottom of the tank, but for de-enamelling purposes it is necessary to have them at the sides only, and keep them well clear of the bottom so that they will not be covered by sludge. It is intended to use "Torribar" elements sheathed in pure nickel, and stress-relieved at or above 650 deg. C. after manufacture. Nickel, if not stress-relieved, may suffer from caustic embrittlement as a result of contact with molten anhydrous caustic soda, whereas mild steel is only so attacked by caustic solutions of 35 to 70 per cent. strength.

One very great advantage of "Torribar" heating elements is that, in the unlikely event of one of them failing in use, it may be replaced without any disturbance of the rest of the plant. In constructing such a plant, the following points should be observed.

### Design of Plant

The tank for holding the molten caustic soda should be of welded mild steel plate at least 1 to 1¼ in. thick. It is most important that the corners should be welded inside as well as outside. The inside weld should be made first, and should extend through half the thickness of the plate, and a "U" should then be chipped from the outside to a depth of two-thirds of the thickness of the plate, and filled with weld metal (Fig. 6). Electric welding is recommended using any good-class covered electrode conforming to B.S.S. 639, Class A.

The caustic tank should be efficiently heat insulated, and should be fitted with an insulated lid. This might be in two parts, hinged at the sides of the tank, for easy operation of the lifting gear for the basket; alternatively, it might be made to slide horizontally in a sand seal.




Courtesy of *Electric Resistance Furnace Co., Ltd.*

Fig. 5.—Molten-Caustic De-Enamelling Plant Fitted with "Torribar" Electric Immersion Heaters.

The baskets or crates to contain the work should be so designed that the overhead lifting gear can pick them up with an automatic hook. It should not be necessary for a workman to hook the lifting tackle on to the basket by any manual method necessitating approach to the tank. Baskets should be of ample strength. Thin expanded metal sides are not recommended, as they are too readily distorted at the working temperature. The strength of mild steel above 500 deg. C. is very low, so that ample sections should be provided.

The baskets should be lowered into the tank along guides to avoid the risk of damaging the heating elements. The caustic tank should be behind a screen, preferably made of wood or sheet steel and extending from floor to roof with a double glass window through which operations may be watched. Provision should be made for the easy renewal of the glass. A double window should be sufficient protection against caustic splashes: if the inner glass becomes cracked, the outer one is likely to remain intact. Controls for the overhead crane for lifting the work in and out of the tank should be in front of the screen.

Arrangements for pre-heating the work before it is put into the caustic will ensure that it is perfectly dry, and will therefore prevent splashing. Preheating also conserves the heat of the caustic. In many cases it will be possible to use waste heat from the enamelling stoves for this purpose. Electrical contacts on the plant should be adequately protected against corrosion, and they should be examined and cleaned at frequent intervals.

### Method of Operating

The de-enamelling operation is carried out by packing the parts to be treated in a crate, or on a perforated tray, and lowering them into the molten caustic soda. Workmen carrying out this operation should be completely protected against splashing of the caustic, by a screen, as already recommended. After about 3 to 5 minutes' immersion, the tray or crate is lifted out of the bath and allowed to drain. When the caustic has solidified, the parts should be unloaded from the crate by men wearing goggles and rubber gloves, and should be allowed to cool thoroughly before being passed on to the rinse tank. Here, they should be rinsed and wire brushed to remove the adhering caustic soda and sludge.

It is important that sheets which are closely packed together and coated with caustic should not be lowered into the rinse tank in the crate, even though the water is cold, as this would be liable to cause a violent reaction. They should be handled one at a time, and, provided this precaution is observed, the water in the rinse tank may be warm, but not exceeding 150 deg. F. This point is stressed, because the instruction previously quoted from Prentiss's account, in which rinsing in boiling water is recommended, may be a highly dangerous procedure.

The caustic soda bath can only be used for a limited period without removing the sludge, which is formed by the partly dissolved enamel.

Fig. 6.

The period varies from 5 to 10 hours. After continuous use for this period, the caustic soda becomes very thick, and its efficiency is impaired. When this stage is reached, a tray 10 to 12 in. deep, with perforations in the base, is lowered to the bottom of the tank, and the caustic soda is allowed to cool by about 100 deg. C. (*i.e.*, to 400 to 450 deg. C.). While this is taking place, the sludge sinks to the bottom and collects in the tray. Heat is then applied again, bringing the bath back to its working temperature of about 550 deg. C., and the tray of sludge is lifted out. Fresh caustic soda is then added to the bath to make up to the required level.

In America, the practice originated of blowing dry steam into the caustic bath immediately prior to letting the sludge settle. Theoretically the bath becomes rich in sodium oxide (Na O), and one of the objects of the steam treatment is to re-form sodium hydroxide (NaOH). It has also been suggested that this treatment causes the sludge to settle more rapidly than it otherwise would. The steam is introduced through a perforated pipe running the whole length of the bottom of the caustic tank and the operation is carried on for 15 to 30 min. It

causes the caustic to boil and roll, but is said (by those who have used it) to be carried out without danger. Quite obviously, care must be taken to ensure that the steam really is dry. The introduction of any quantity of water into the hot caustic might cause an explosive reaction.

### Disposal of Sludge

The disposal of the sludge from the molten caustic process calls for special mention, and it is even more important to take precautions against the possibility of accidents, than in the case of the sludge from the caustic solution process. This is evident from the following typical percentage analyses of the two kinds of sludge:—

| | Sludge from molten caustic. | | | Sludge from caustic solution. | |
|---|---|---|---|---|---|
| | 1. | 2. | 3. | 1. | 2. |
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| NaOH | 67.1 | 67.85 | 43.6 | 22.5 | 31.5 |
| $Na_2O.SiO_2$ | 20.55 | 11.59 | 13.8 | 20.1 | 19.9 |
| $Na_2O.Al_2O_3$ | — | 2.22 | 1.9 | 1.5 | 2.65 |
| $Na_2B_4O_7$ | 6.45 | 7.72 | 8.0 | 9.0 | 5.9 |
| $Na_2CO_3$ | 3.25 | 6.81 | 5.2 | 1.5 | 1.2 |

The molten caustic sludge contains a very high percentage of free caustic soda. If waste ground is available the safest method of disposal is to prepare a sludge bed of sufficient depth, banked and fenced round, into which the sludge can be dumped, and, after a sufficient quantity has accumulated, buried by returning the banks to the pit itself. Neutralisation of the sludge with waste pickle acid has also been suggested.

### Safety Precautions

Whichever method of de-enamelling be used, either caustic solution or molten caustic, it is highly important that the whole process should be carried out under the supervision of a responsible person, and with every possible precaution to minimise the risk of accidents.

Reference has already been made to the need for placing the caustic soda tank behind a screen. The controls of the overhead crane which lifts work in and out of the tanks should be in such a position that the workman is completely protected while he operates them. Then, if the work entering the caustic tank is not quite dry (in the molten caustic process) or if there is any mishap to the lifting tackle, no personal injury will be suffered.

Whenever it is necessary to go behind the screen and approach the caustic tank, during the unloading of work from the crate, the addition of fresh caustic to the tank, the disposal of sludge, or when repairs are being carried out, the wearing of goggles should be made compulsory. Goggles of modern design can be worn for reasonable periods without discomfort and, in the men's own interest, their use should be insisted on. The right attitude of mind is helped if an example is set by the management. Additional protection is afforded by a face mask which is particularly desirable when drums of caustic are being unpacked and transferred to the tank, or under emergency conditions as when an electric-heating element has to be changed.

Use should also be made of other types of protective clothing. Rubber Wellington boots should be worn with the trouser legs of the man's overalls outside the Wellingtons. Rubber or thick cotton gauntlet gloves should also be worn.

When any dangerous operation is being carried out, such as the inspection of the plant for suspected faults, taking samples from the caustic tank, or handling sludge, it is desirable for a senior man to supervise the operation, and be responsible for the use of all necessary precautions. Help should be available, under such circumstances, in case an accident occurs.

Water in which caustic soda is to be dissolved should not be hotter than 150 deg. F. before the addition of the caustic; otherwise violent ebullition may occur. Vessels which have contained caustic should be washed out as soon as possible, and while they are cold. One individual should be made responsible for the frequent and regular inspection of all safety appliances, and for maintaining them in good condition.

Taken all together, these precautions may appear to call for an undue amount of attention, but they are set out here on the principle that it is better and cheaper to prevent accidents than to pay for their consequences. The ordinary workman cannot be expected to have a full knowledge of the properties of caustic soda. It is a chemical which can be used in safety if the risks involved are appreciated by those in authority, and the precautions outlined above are attended to.

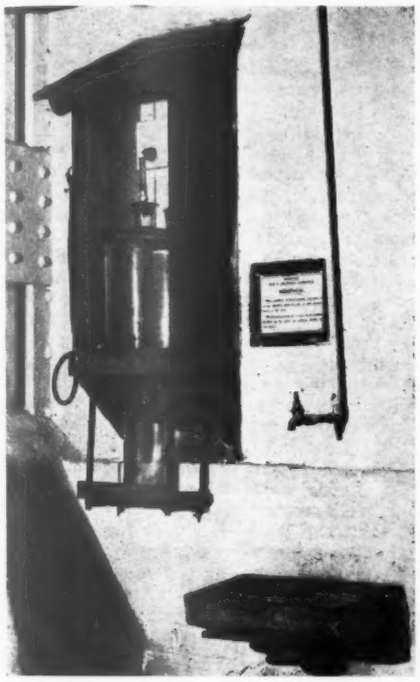


FIG. 7.—AMMONIUM CHLORIDE EQUIPMENT FOR USE WHEN CAUSTIC SODA GETS ON SKIN OR CLOTHING.

### Treatment of Caustic Burns

In the event of caustic soda getting on to the skin, or in the eye, the greatest safeguard lies in effective first-aid treatment being available on the spot. Where there is any risk of caustic soda burns occurring, the following should be available:—

(1) A large (5 gallon) aspirator containing a 5 per cent. solution of ammonium chloride and fitted with a rubber tube of about 10 mm. bore and a pinchcock (Fig. 7). As soon as caustic soda comes into contact with the skin or clothes, the man concerned should immediately open the pinchcock and allow a rapid stream of the solution to flow over the part affected. If there is any delay, and the caustic has actually burned the skin, the affected part should be drenched with ammonium chloride solution for 10 to 15 minutes and then washed continuously either with running water or "normal saline"* for a period of an hour. The burn should then be treated by a doctor as a heat burn.

* "Normal saline" is "Liquor Sodii Chloridi Physiologicus" of the British Pharmacopoeia, *i.e.*, a sterilised solution of common salt in water containing 9 grams per litre.

(2) Either "normal saline" or boracic lotion, in case caustic gets in the eye. The treatment consists of irrigating the eye immediately with one of these solutions for one hour, continuously. Experience shows that this treatment reduces the time of recovery from several weeks to a few days. Suitable bottles and shelving for eye lotion are illustrated in Fig. 8.

### Choice of De-Enamelling Process

In conclusion the factors influencing the choice of a de-enamelling process may be summarised. Where speed is not important, but there is a steady flow of flat or nearly flat sheet metal parts to be de-enamelled, the caustic solution method with its comparatively low capital cost has proved itself to be satisfactory. In order to get the most economical results with this process, it is probably essential to run a day and a night shift. The consumption of caustic soda is said to be about $\frac{1}{3}$ lb. per sq. ft. of enamel treated.

Where speed of operation is important, and particularly where parts of a bulky nature, such as enamelled sinks, washing-machine tubs, geyser bodies, etc., are to be de-enamelled, the molten caustic method has an obvious advantage in that a large number of articles can be enamelled during an 8-hour shift, and there is no need to operate the plant during the night. The consumption of caustic soda by this method is probably two or three times as great as by the solution method. Molten caustic is also desirable when acid-resisting enamel is to be removed.

FIG. 8.—EYE-WASH BOTTLES CONTAINING EITHER "NORMAL SALINE" OR BORACIC LOTION.

The author wishes to thank those firms who have so kindly allowed him to see their de-enamelling plants, and in particular J. Gray & Sons, Limited, and the Electric Resistance Furnace Company, Limited, who have supplied details of the plants they have designed.

## DISCUSSION

### Caustic Reclamation

The discussion of Mr. Evans's Paper by members of the Midland Section of the Institute of Vitreous Enamellers was opened by MR. BORE, who asked if there was any satisfactory way of recovering the caustic in the molten caustic process.

MR. EVANS replied to this question that the only method he had seen in use was on a plant where the solution method was used as well as the molten caustic. The sludge from the molten caustic tank was used to make up the strength of the solution in the wet process tank. A chemical method of recovering the caustic would be more expensive than it was worth.

MR. HALLSWORTH asked if Mr. Evans had had any experience of de-enamelling acid-resisting enamel with the wet process, and the additional

time it took to remove the enamel. He was rather sorry that Mr. Evans discarded the testing of the solution and wondered whether this had been done from experience or purely for scientific reasons. Even if, as was suggested in the Paper, the double titration method did not show accurately the free caustic content of the bath, it did give the relative strength of the solution, if only expressed as the number of cubic centimetres of acid for a given quantity of solution.

He did not consider it sufficient simply to suggest that a certain quantity, or regular daily quantity, was added to the solution, when he had said that it took from 8 to 20 hours for the de-enamelling to take place, and some enamels would neutralise more caustic than others. He had found from experience that the double titration method worked quite well in practice, and was a definite means of controlling the strength of the solution. It was possible, for example, to have the solution too strong, if there was insufficient heat available to bring the stronger solution to its boiling point.

He had been consulted because an executive was not satisfied with the efficiency of his plant. Further additions of caustic reduced, rather than increased, the efficiency. This was due to the increased boiling point of the solution and the inability to bring the bath up to the increased temperature. When the titration method was used, it was found that the solution was too strong and reduction of this strength thus enabled the solution to be brought to its boiling point, and it gave satisfactory results.

### Strength Testing Methods

MR. EVANS said that he did not exactly reject the titration test, but in the titration, not only the free caustic, but also the caustic soda in combination with various constituents of the enamel, might be included. One assumed that the sodium silicate was present in a 1 to 1 ratio. There was no reason for that assumption, and he did not think it was known whether caustic soda combined with silica would still act as a de-enamelling agent. He thought that if it did continue to function, it would be slower in its action. He considered that possibly the case to which Mr. Hallsworth referred, of a solution being found too strong, was not because too much caustic was added when it slowed down. The slowing down was due to the fact that the sludge was not properly removed. However much caustic was added, if the sludge was not removed, the whole process would be slowed down, on account of increased viscosity of the solution.

MR. HALLSWORTH explained that the plant he had mentioned had not been used long enough to form any sludge. Too much caustic had been added and the temperature not increased accordingly. He wished to use this as an illustration of overloading the tank with caustic and of the benefit of a control test of some description. The double titraton method had worked satisfactorily.

MR. EVANS agreed that if the method worked satisfactorily this was the best reason for using it. He suggested finding by experiment the amount of caustic required. In his statement he had said that in practice this varied from one plant to another. Bearing in mind the differences in operating conditions, the amount of caustic to be added each day or each week would be decided upon from practical experience —in finding how long one could go on using the solut'on before it became too slow in its action, and how much caustic must be added to rejuvenate the solution.

### Operating Details

MR. GRAY referred to the question of adding caustic soda without increasing the temperature. The more caustic soda was added, the thicker became the solution and there was no movement of heat through it.

Regarding rejuvenating the solution during work, the speaker's company had found after long test that it was better to start off with 50 per cent. solution and add no caustic at all during the life of the solution. He mentioned two plants that actually worked about 3 weeks without being cleared out, and after de-enamelling 5,500 sq. ft. of the work the tank was rendered inefficient, yet the caustic solution still contained 45 per cent. of free caustic. This point had been discussed quite a lot, but the tank could not work because the free caustic in the solution was not able to do its work owing to the presence of sludge from the enamel.

When starting off with a clean tank it would probably be found that with an ordinary regular load of soft white or coloured enamels, the de-enamelling took about 7 hrs. for the first load. As t me went on, owing to the chemical effect, the time would be lengthened to about 12 hrs. Mr. Evans had mentioned 24 hrs., but he could hardly conceive that, because he knew of a number of these plants which worked 3 to 4 weeks without being stopped at all, and at the end of that run the process only took 10 hrs. and the sheets were mostly reconditioned ones. It did not make any difference whether the sheets were shop scrap, or whether they were sheets which had been in use on the District Railway for a number of years.

Referring to the removal of acid-resistant enamel, he said that he had taken this up with Mr. Thomason, who did not think it would take any longer, but on test it was found that the best acid-resisting enamel only took 2 hours longer than ordinary soft enamel. The test was carried out by putting the acid-resisting enamel in the same crate with the ordinary soft enamel, and after lifting the stripped plates out and putting the acid-resisting ones back, it was found that the strongest took only 2 hours, whilst some took only 1 hour, longer than the ordinary enamels.

He had in his possession a four weeks' actual test, 24 hrs. a day, and offered to furnish the Chemical Resistance Test Sub-Committee with copies of it.

### Burning Out of Tanks

Mr. Gray then referred to the burning out of tanks. The author had said that it was mostly due to the method of firing. Mr. Gray said he would like to have the opportunity of designing a simple furance, either coal, gas or oil, that would give a very long life to a tank using the molten caustic method. That, he considered, would not be a problem at all to the furnace maker, because there were many thousands of cyanide baths working at a temperature of 495 to 620 deg. C. in ordinary mild-steel tanks. Everything depended upon the design and method of firing regarding the life of the tank, and any furnace maker should overcome this difficulty.

Regarding the welding of the tank, had Mr. Evans considered the advantages of hammer-welding? If he wished himself to make a tank for the molten caustic method, he would certainly have it hammer-welded. This was, in his opinion, the most satisfactory way of making a tank where there had to be 1, 1½ or 2 in. of metal. When properly done by a skilled man, this would give as good a life as any other part of the tank. In connection with the protecting screen, he wished to ask Mr. Evans whether, in his opinion, it was necessary to have a screen with the solution plant. His company had definitely found it unnecessary. They had designed special protective clothing, including a face mask with eye piece, and this was more comfortable than goggles. The shield was held away from the face. On the question of first aid, he had been told that ordinary vinegar and citric acid had been found more effective than the solution mentioned by Mr. Evans.

### Labour Costs

MR. W. TODD said that he had seen a plant in London which worked on a 24-hour cycle. As far as he could gather, the subject was largely concerned with labour costs. They did not believe in keeping gangs of men on the plant waiting for the loads. A load was immersed and left in the tank for 24 hours. It was found that previously, owing to the varying shapes of the work, some finished in 10, 14 and 15 hours, and it meant keeping gangs of men available to pull the loads out.

MR. GRAY intimated that if anybody would like to see a plant which was giving good results, he would be pleased to arrange for them to do so.

### Safety Methods

MR. EVANS, referring to Mr. Gray's comments on hammer-welding, conceded that he might be right. Tanks could be very satisfactorily welded by the electric arc method, but hammer-welding was liable to leave scale inclusions which would be speedily picked out by molten caustic.

He then referred to the question of using a screen, even for the solution method. He felt very strongly that it was far better and cheaper, and promoted better feeling with the workpeople, to prevent accidents than to try to patch them up afterwards. It was quite true that people could use caustic soda plants for a long period, apparently without serious accidents, but the possibility of serious injury being inflicted on workmen ought to receive adequate consideration, particularly as it was such a simple matter to eliminate most of the risk.

The casual way in which chain and pulley lifting tackle was handled, directly over tanks containing nearly boiling caustic soda solution, by men wearing absolutely no form of eye protection, was simply inviting trouble. The proper thing to do was to use adequate safety devices and prevent accidents. A man had only to get one splash of caustic and the sight of an eye might be lost. This was very easily done by dropping something into the tank. When the whole thing was put behind a screen, it was just as easy to work the lifting tackle and no risk at all was involved. Whether using the molten caustic or caustic solution method, a screen should be used.

Commenting on the pumping of sludge out of the tank after it had been diluted, he said the common practice of shovelling the sludge out of the tank had been proved to be dangerous and should be avoided.

### Accident Treatment

As to vinegar instead of ammonium chloride for the treatment of caustic burns, he had never had any experience of it, but he had had experience with ammonium chloride and believed it to be the best of all treatments for caustic burns, as it formed sodium chlor'de and immediately neutralised the caustic effect. In the experience of his firm it had materially reduced the time lost by caustic burns and the men ran for this solution immediately they got the slightest burn and drenched the part with it, because they knew it worked.

MR. TODD also advised the provision of protective clothing and steps to ensure that the men used them. Sometimes they found that "familiarity bred contempt."

### Caustic Maker's Views

MR. H. E. JONES endorsed Mr. Evans's remarks on the dangers involved in the use of both the molten reagent and hot strong solutions. It was of the utmost importance that adequate safety precautions should be taken. Anyone, like Mr. Evans and himself, who had had experience of the manufacture of caustic soda on a large scale, would realise that careless methods of working without suitable devices to ensure safety must sooner or later result in serious accidents.

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The increasing demand for high-strength close-grained iron castings calls for improved metal. In comparison with the accepted standards of the past, the modern high quality casting requires lower total carbon and phosphorus, with a closer range in silicon. The Ironfounder can now meet this demand at a reasonable cost by the use of Stanton-Dale Refined Pig Iron.

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For the treatment of caustic burns, it was true that weak acids such as acetic and citric acids, and also sodium bicarbonate, had been used with reasonably satisfactory results, as they had the effect of destroying the causticity of the material. Investigations by the medical and safety officers at the works of I.C.I. (Alkali), Limited, had, however, shown that ammonium chloride was remarkably effective. It acted as a weak acid destroying the causticity and forming sodium chloride and ammonia.

### Mechanism of De-Enamelling

In connection with the actual process of de-enamelling, it would be impossible to state without a long and difficult investigation what actually took place in the bath. In caustic soda the full alkaline strength of the strong alkaline oxide—sodium oxide—was available to destroy acids and to combine with acid oxides.

The majority of the oxides in the enamel were chemically of such a nature that they combined with the sodium oxide, forming such products as various sodium silicates, sodium borate, sodium aluminate, etc. If these products remained in solution, the alkali intensity of the bath would progressively fall and its power to remove further quantities of enamel would gradually decrease. The effect would result from the fact that sodium oxide became less active when it combined with acid oxides. As, however, the acid oxides in the enamel, of which silica was the chief, were relatively weak, the alkaline salts, which they formed by combination with the sodium oxide, would be relatively strong alkalis and the bath would probably retain a considerable degree of de-enamelling power until a fair accumulation of acid oxides in the bath had occurred.

Unfortunately, the process was complicated by the fact that many of the alkaline salts formed by combination with the acid oxides were insoluble or had a low solubility in the caustic solution and especially in molten caustic. They therefore separated out rapidly as a sludge with the result that the bath, especially in the case of the molten reagent, became thick and viscous and contact between the liquor and the articles to be de-enamelled was hindered. It was evident that a highly complex phase system was involved and in order to obtain a clear picture of the conditions, it would be necessary to determine the actual composition of the liquid and solid phases separately and not merely the composition of the wet sludge, *i.e.*, a mixture of the liquid and solid phases.

The determination of such data would be a difficult problem, but it could probably be done by the application of methods employed in phase rule investigations in physical chemistry. The knowledge thus obtained might throw some light on the question whether the decline in the activity of the bath was due primarily to a fall in the alkali intensity of the liquid caused by the accumulation of alkaline salts in solution or to the prevention of intimate contact between the liquid and the enamel caused by the presence of sludge. Some guide might thus be obtained to the most effective method of maintaining the activity of the bath by keeping up the alkali intensity of the liquid or by some method of continuously removing the sludge formed. Such an investigation might also throw light on the problem of analytical control and a method based on potentiometric titration, which was now being extensively employed by analytical chemists, might be devised.

### Control by Temperature

MR. GRAY said that most people just worked on the temperature of the bath. They started off with a 50 per cent. solution and took the temperature of its boiling point, then adjusted the caustic additions to maintain this temperature.

MR. HALLSWORTH said that the opinion was held that all raw materials for making enamels must be carefully weighed and control systems had been inaugurated. To start a new process and say that one would add so much when one felt inclined, was, in his opinion, quite wrong. A process must be controlled and possibly a simple method of control could be found. The method of carrying out the control did not matter as long as it was not a "hit and miss" method.

MR. GRAY considered that this did not follow in the case under review. Assuming one commenced with a solution of 50 per cent. and a week's supply of work to be de-enamelled, the boiling point was known and the plant should work at 275 deg.; it was further known that at the end of the week's work the caustic soda would still amount to 45 per cent., but would not work owing to chemical breakdown; then no other test, in his opinion, was required. If it were considered that a method of testing was required, then one was set out in his own report.

MR. HALLSWORTH said that if one spoke of "free caustic content," one encountered the difficulties that Mr. Evans suggested. He never used the term "free caustic soda" but "the concentration of the alkalinity of the bath."

MR. GRAY suggested that this matter could be investigated.

### Sludge Constituent Reclamation

DR. MARTIN held the view that many valuable things might be thrown away in the sludge. Using white enamel, the opacifier might finish up in the solution. He asked whether it was possible to recover it. If the sludge were left about long enough it would turn into carbonate, or it might be exposed to flue gases, etc.

MR. EVANS said that waste pickle acid could be used to render it harmless and was a simple method.

### Caustic Embrittlement

A MEMBER asked if immersion heaters would be practicable in the solution method. His firm had found it was not so much the welding of the tank as the expansion of the tubes that was the difficulty. When they were heated they pushed themselves out of the tank. He cleared the tank periodically when sludge formed 9 in. from the bottom. Immersion heaters might dispose of that trouble. They were having difficulties with the tank at the moment and it had burnt through at the junction of the tube to the sides of the tank.

MR. EVANS said that inter-crystalline corrosion was almost bound to occur in time if the tank was not stress-relieved. He did not see why immersion heaters should not be used for caustic solution method. Also, they might be encased in mild steel instead of nickel, as in the molten caustic method. Stress-relieved mild steel, he said, was resistant to 50 per cent. caustic solution. It was a sounder method of heating the solution than to heat the tank from the outside, as there was bound to be a temperature gradient between the two.

Attempts had been made to use the sludge, but they had not been very successful. The process might, he considered, cost more than was justified.

### War Savings

The most popular of the six principal Savings Group systems is the 30-week cycle method, which provides for the purchase of 15s. National Savings Certificates by instalments. It is worked in cycles, each covering a period of 30 weeks. Each member of the Savings Group signifies beforehand the number of certificates he intends to purchase during the cycle, and subscribes 6d. a week for each certificate. Certificates are then allotted to members by ballot. The element of chance as to which of the members draws the first certificate is perhaps the special attraction in this method of saving. New Savings Groups are being formed at the rate of over 1,500 a week, and the object of the campaign is to get more than 2,500 new groups being formed every week. It is estimated that there are over 350,000 places where groups can be usefully established.

## Republic's 1,200-ton per day Blast Furnace

The Warren blast furnace of Republic Iron & Steel Corporation was originally built with an 18-ft. 6-in. hearth. In 1930 this was enlarged to 27-ft. dia. It had a good hearth jacket of the bolted segmental type reinforced by steel bands. The old shell, while comparatively new, had considerable batter due to the large mantle and small top diameters, and aggravated by the fact that the old furnace was very short. Retaining the hearth jacket, tuyere jacket, columns, mantle, designs were prepared providing for a furnace 15 ft. 1½ in. higher, and with a 33½ per cent. increase in working volume. The 1939 dimensions of the furnace compared with those existing in 1930 in parentheses are as follow: Hearth diameter, 27 ft. (27 ft.); bosh diameter, 30 ft. (28 ft. 6 in.); stockline diameter, 19 ft. 6 in. (19 ft.); large bell, 14 ft. 5 in. (14 ft.); small bell, 6 ft. (5 ft.); bosh angle, 83 deg. 17 min. (86 deg. 36 min.); height from centre line of tuyeres to large bell closed, 89 ft. 3 in. (77 ft.); height from iron notch to tunnel ring, 106 ft. 7½ in. (91 ft. 6 in.). The furnace now has a capacity of 1,200 tons per day. The old furnace, which was blown out on August 12, 1939, made 1,973,583 gross tons on the 1930 lining. The furnace was blown down only about 30 ft. from the top platform to provide a cooler top for dismantling operations which started on August 14, 1939, the furnace being blown in on November 3, 1939.—"Blast Furnace and Steel Plant."

## Patent Specifications Accepted

*The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.*

516,684 SACHTLEBEN AKT.-GES. FUR BERGBAU UND CHEMISCHE INDUSTRIE. Desulphurising iron or iron alloys.

516,734 WILLEY, F. H. Wear-resistant metal alloy.

516,867 WESTBERG, S. Heat-resistant chromium-containing alloy steels, and process for the production thereof.

516,920 DUNCAN, STEWART & COMPANY, LIMITED, CROSBIE, J. B. TALBOT-, and MACQUISTEN, A. P. S. Method for the production of hollow metallic cases.

516,944 BEAVER, C. J., LISHMAN, R. C., and GLOVER & COMPANY, LIMITED, W. T. Means for making a joint between two parts by casting metal round them.

517,015 PEACE & SONS, LIMITED, J., and PEACE, W. H. Apparatus for forging, hammering, and the like.

517,035 STEVENS, A. H. (Stringfellow, H. A.). Method of and apparatus for reducing the cross-sectional area of wire, rod, bar, strip, or like bodies.

517,049 PYRENE COMPANY, LIMITED. Improving the resistance of metals to corrosion.

517,083 SERI HOLDING SOC. ANON. High quality alloys, and process for their manufacture.

517,118 POLLAK, J. E. (Vereinigte Oberschlesische Huttenwerke Akt.-Ges.). Steels, and the application thereof.

517,151 THYSSEN-HUTTE AKT.-GES., A. Casting of hollow metal billets or blocks.

517,233 DUNLOP, S. (Ferror Steel Corporation). Annealing-box alloys.

517,273 MERCER, R. (American Ore Reclamation Company). Grate bars for sintering machines.

517,365 SOC. D'ELECTRO-CHIMIE, D'ELECTRO-METALLURGIE, ET DES ACIERIES ELECTRIQUES D'UGINE. Treatment of metallic baths by certain solid materials.

517,366 SOC. D'ELECTRO-CHIMIE, D'ELECTRO-METALLURGIE, ET DES ACIERIES ELECTRIQUES D'UGINE. Far-reaching deoxidation of steel by carbon.

517,367 SOC. D'ELECTRO-CHIMIE, D'ELECTRO-METALLURGIE, ET DES ACIERIES ELECTRIQUES D'UGINE. Process for the manufacture of cast iron.

517,387 LUCAS, LIMITED, J., and HINKS, S. J. Machines for shearing metals.

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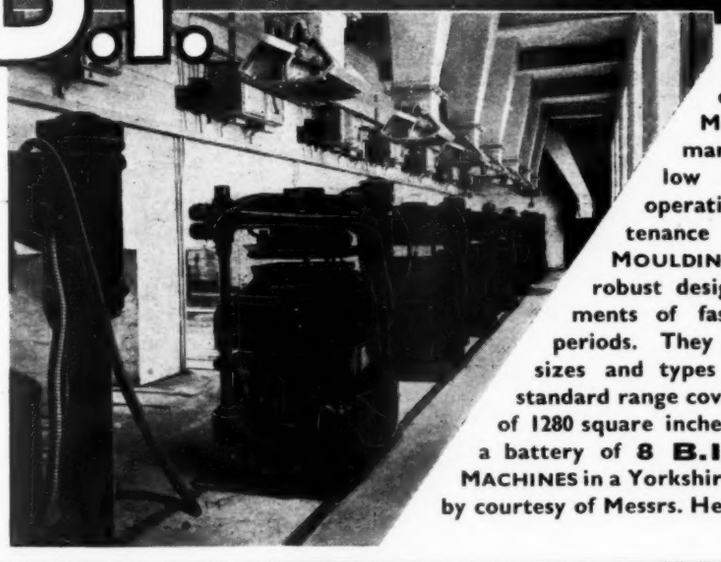
# B.I. MAGNETIC MOULDING MACHINES *in a* YORKSHIRE FOUNDRY



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# The Week's News in Brief

## Trade Talk

STEWARTS AND LLOYDS, LIMITED, have received a contract for the supply of low-pressure pipework for Fulham Borough Council.

THE AMERICAN BUREAU of the Census reports that production of malleable-iron castings in the U.S.A. in 1939 was 480,578 tons, as against 289,914 tons in 1938 and 602,278 tons in 1937.

A FARM-BY-FARM collection of scrap iron and steel is to be organised in Warwickshire. A letter of appeal has been sent from the Iron and Steel Control, Ministry of Supply, to 3,200 farmers.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, of Loughborough, have opened new branch offices at Daimler House, Wilmslow Road, Rusholme, Manchester, 14. The offices at Haworth Buildings, Cross Street, Manchester, have been vacated.

THE SOUTH AFRICAN BRANCH of the Institute of British Foundrymen has decided to award a diploma to the individual who, during the year 1939, "has been responsible for the most outstanding accomplishment redounding to the benefit or knowledge or progress in the industry."

LEYLAND MOTORS, LIMITED, of Leyland, Lancs, have recently delivered three trolley buses to the municipality of Edmonton, Canada. The bodies were built by Park Royal Coachwork, Limited, London, and the electrical equipment was manufactured by the General Electric Company, Limited, Birmingham.

FOURTEEN COMPLETE trolley buses are being built by Ransomes, Sims & Jefferies, Limited, of Ipswich, to the order of the Crown Agents for the Colonies, for public transport services in Trinidad, British West Indies. The vehicles will have all-teak bodies to seat 31 passengers and will be equipped with 40-h.p. Ransomes standard light-weight traction motors.

ENCOURAGED BY OFFERS of support from all quarters, the Committee of the Paris International Trade Fair (Foire de Paris) announce that their 32nd annual trade fair will be held, as usual, from May 11 to 27. The international aspect of the Fair will be developed to an even greater extent this year. Already important national sections have been promised from Italy, Holland and Spain, as well as displays from Switzerland, Belgium, etc. Thus, not only will the wishes of the French exhibitors be fulfilled, regarding the continuance of the Fair, but also those of overseas manufacturers, many of whom will be exhibiting for the first time. An inventions competition is again being organised in connection with the Fair. Last year 769 inventions were submitted by 517 competitors, representing 15 countries. In spite of adverse financial conditions, the Committee of the Fair are making no changes in the value of the prizes this year, the figure devoted to this purpose being still 25,000 francs, as on previous occasions.

## Personal

MR. JAMES CRIGHTON, manager of the Wallace Foundry, Dundee, has received presentations from the staff upon his retirement after 46 years with the firm.

MR. W. J. HICKENBOTTOM, foundry foreman of Bagshawe & Company, Limited, of Dunstable, was, upon completion of 25 years' service with the firm, presented with a gold cigarette case by the managing director, Mr. A. W. G. Bagshawe.

LIEUT.-COL. B. H. LEESON, a director of A. Reyrolle & Company, Limited, manufacturing electrical engineers, Hebburn-on-Tyne, has relinquished command of his unit on active service as a result of a decision of the Ministry of Supply that his services are required in the national interests of production and export. Lieut.-Col. Leeson has had 32 years' service with the Territorial Army.

PROF. A. L. MELLANBY, D.SC., LL.D., has been elected an honorary life member of the Institution of Mechanical Engineers. His interest in foundry work has always been most marked. He gave the Edward Williams Lecture when the Institute of British Foundrymen last held its annual conference in Glasgow, and he now presides over the Research Committee on High-Duty Cast Iron for General Engineering Purposes organised by the Institution of Mechanical Engineers. Prof. Mellanby is to deliver the Thomas Lowe Gray Lecture to the Institution on Friday, March 15, when his subject will be "Fifty Years of Marine Engineering."

## Obituary

CAPT. JAMES B. DRYDEN, a director of Thomas Dryden & Sons, Limited, engineers and brass and iron founders, of Preston, died last month, at the age of 53.

MR. A. J. RAINE, chairman and joint managing director of Raine & Company, Limited, iron and steel manufacturers, of Newcastle-upon-Tyne and Derwenthaugh, died last Friday.

MR. JOHN TALMAN, a well-known figure in the iron trade in the West of Scotland, died last Saturday. He served with the Dalmellington Iron Company, Ayrshire, for 61 years, retiring from the post of general manager of the company's stores in 1931. He was in his 82nd year.

THE DEATH took place last week, at Larbert, of Mr. John Oliver, J.P., formerly representative of the Carron Company in Scotland, Northern England and Northern Ireland for cooking apparatus. He was 79 years of age and retired in May last year after 55 years' service with the company. He went from Saracen Foundry, Glasgow, to the drawing office at Carron, and later became chief clerk in the cooking apparatus and gas departments, afterwards doing duty as foreman in the gas-appliance fitting shop.

MR. H. B. TOY, a veteran industrialist of Tees-side, who celebrated his golden wedding in December last, died at his residence at Saltburn last week. A native of West Bromwich, he was trained as a mechanical engineer at the Birmingham works of Tangyes, Limited, and afterwards was with Bolckow Vaughan & Company, Limited, Middlesbrough, and Thomas Perry & Son, Limited, of Bilston. Five years as managing director of C. Akrill & Company, Limited, of West Bromwich, preceded his return to Tees-side in 1907, when he established the British Chilled Roll & Engineering Company, Limited, at Haverton Hill. Of this company he remained chairman and managing director until his retirement. Mr. Toy was for very many years a member of the Iron and Steel Institute and had been President of the Cleveland Institution of Engineers, the Cleveland Scientific and Technical Institute, the Tees-side Chamber of Commerce and the Staffordshire Iron and Steel Institute.

## New A.F.A. Officers Nominated

Mr. L. N. Shannon, vice-president and works manager of Stockham Pipe Fittings Company, Birmingham, and the present Vice-President of the American Foundrymen's Association, has been nominated for the Presidency of the Association. Mr. Herbert S. Simpson, President of the National Engineering Company, Chicago, and a past director of the Association, has been nominated for Vice-President.

Directors nominated to serve three-year terms are:—Henry S. Washburn, president, Plainville Casting Company, Plainville, Conn.; George W. Cannon, vice-president, Campbell, Wyatt & Cannon Foundry Company, Muskegon, Mich.; L. P. Robinson, sales manager, Werner G. Smith Company, Cleveland; Harold J. Roast, vice-president, Canadian Bronze Company, Montreal, Canada; and B. D. Claffey, Grey Iron Division, General Malleable Corp., Waukesha, Wis.

## Applications for Trade Marks

*The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—*

"EVERTITE"—Lock-nuts. EVERTITE LOCKNUTS (1938), LIMITED, 95A, Chancery Lane, London, W.C.2.

"YCOL"—Metal castings and alloys. WHYTE & COLLINS, Kelvin Works, Hawkins Street, Fenton, Stoke-on-Trent.

"TELLOK"—Supports of common metal for use in building. D. H. GREEN., 46, Roedean Crescent, London, S.W.15.

"JAMES"—Concentrating tables for the treatment of ores, metalliferous sands, etc. HOLMAN BROS., LIMITED, Camborne.

"AEROFLEX"—Electric switchgear, etc. PARMITER HOPE & SUGDEN, LIMITED, Newton Avenue, Longsight, Manchester, 12.

## Reports and Dividends

**Blakey's Boot Protectors, Limited**—Interim dividend of 7½ per cent.

**United Steel Companies, Limited**—Interim dividend of 2½ per cent.

**National Gas & Oil Engine Company, Limited**—Dividend of 2½ per cent.

**R. & W. Hawthorn Leslie & Company, Limited**—Interim dividend of 3 per cent.

**Thos. W. Ward, Limited**—Interim dividend of 3¾ per cent. on the ordinary shares.

**Boulton & Paul, Limited**—Ordinary dividend for the year ended September 30 of 5 per cent.

**John Baker & Bessemer, Limited**—Net profit for 1939, £65,824; ordinary dividend of 10 per cent.

**Clarke Chapman & Company, Limited**—Dividend of 12½ per cent. on the ordinary shares for 1939.

**British Oxygen Company, Limited**—Final dividend on the ordinary stock of 10 per cent., making 17 per cent. for 1939.

**Spencer (Melksham), Limited**—Net profit for the year ended September 30 last, £7,814; brought in, £913; dividend of 6¼ per cent.; carried forward, £8,407.

**Beans Industries, Limited**—Net profit for year to November 30 last, £123,911; brought in, £20,320; additional tax reserve, £60,000; pensions, £5,000; general reserve, £30,000; preference and ordinary dividends, £28,700; carried forward, £20,531.

**James Booth & Company (1915), Limited**—Net profit for 1939, after providing for depreciation, taxation and fees, £188,212; brought in, £62,933; dividend on the preference shares, £7,280; dividend of 15 per cent. on the ordinary shares, £73,125; to reserve, £100,000; staff fund, £5,000; carried forward, £65,740. Meeting, March 19.

**Mather & Platt, Limited**—Net profit for 1939, after charging depreciation and making provision for doubtful debts, increased taxation and exceptional items arising from the war, £146,867; brought in, £83,019; dividend on the preference stock at the rate of 5 per cent., £20,000; ordinary dividend of 10 per cent., £136,366; carried forward, £73,520.

**Hammond Lane Foundry Company, Limited**—Profit for 1939, after providing for depreciation and taxes, £13,470; brought in, £2,279; preference dividend of 6 per cent., £2,655; interim dividend of 5 per cent. on the ordinary shares, £3,750; final dividend of 7½ per cent., £5,469; to general reserve, £1,000; to bad debts reserve, £900; carried forward, £1,975.

## Forthcoming Events

MARCH 12.

*Staffordshire Iron and Steel Institute*:—Joint meeting with Iron and Steel Institute. "Study of 'Strain-Age-Hardening' of Mild Steel," Paper by C. A. Edwards, H. N. Jones and B. Walters, and "Strain-Ageing of Dead-Mild Steel Strip used in the Pressing of Automobile Bodies," Paper by J. W. Rodgers and H. A. Wainwright, at Midland Hotel, Birmingham, at 6.45 p.m.

MARCH 14.

*Institute of Metals (London Section)*:—"Creep of Metals," Paper by J. McKeown, at Caxton Hall, Westminster, London, S.W.1, at 7 p.m.

MARCH 15.

*Institution of Mechanical Engineers*:—"Fifty Years of Marine Engineering," Thomas Lowe Gray Lecture, by Prof. A. L. Mellanby, at the Institution, Storey's Gate, London, S.W.1, at 6 p.m.

*Refractories Association of Great Britain*:—Annual general meeting, at Royal Victoria Hotel, Sheffield, at 4 p.m.

**Institute of British Foundrymen**

MARCH 9.

*Middlesbrough and Newcastle-upon-Tyne Branches*:—Joint meeting arranged by Middlesbrough Branch, at Temperance Institute, Gladstone Street, Darlington. "Development of Steel Foundry Production Methods," Paper by Dr. C. J. Dadswell, at 3 p.m., followed by tea in Queen's Hall, at 5 p.m.

*Scottish Branch*:—Annual general meeting. Presentation of John Surtees Medals. "Production of Some Engineering Castings," Paper by A. Marshall, at Royal Technical College, Glasgow, at 3.30 p.m.

MARCH 12.

*Burnley Section*:—Annual general meeting, and "Commentary on the International Foundry Congress," Paper by W. N. Cook, at Municipal College, Burnley, at 7.30 p.m.

MARCH 16.

*Wales and Monmouth Branch*:—Annual general meeting, and "Moulding Problems in a Steelfoundry," Paper by E. J. Kelly, at University College, Newport Road, Cardiff, at 3 p.m.

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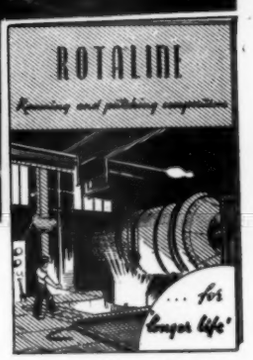


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# Raw Material Markets

The Ministry of Labour has advised employers in the iron and steel trades, together with other industries engaged on war work, to permit their employees to enjoy the benefits of a full Easter holiday; in view of the speed-up in the rate of working for a considerable time past, it is felt that a few days' break should have advantageous results. Wartime production, entailing as it does an increased number of hours, is also an additional strain on workers because of the black-out, which makes it necessary in some cases for operations to be carried out in artificial light even during hours of daylight. The home demand for both iron and steel continues to be insistent, but outputs, too, are steadily expanding and, while primary attention is given to the requirements of the defence programme, quite a substantial amount of material is being made available for ordinary civil consumers. The export market, also, as is indicated by the January returns of the Board of Trade, is not being neglected, and shipments during that month were very gratifying. A revised schedule of prices for scrap iron and steel came into operation on Tuesday, involving increases in the fixed maxima of from 5s. to 10s. It is hoped that this move will result in additional supplies coming on to the market, although it is appreciated that the level of prices obtainable was not to any great extent responsible for the inadequate tonnages previously forthcoming. However, some manufacturers may be induced to consider the demolition of old plant, thus providing a valuable source of supply.

## Pig-Iron

**MIDDLESBROUGH**—The current activity in the shipbuilding industry is resulting in more work among local foundrymen. The production of Cleveland iron is still suspended and stocks at the makers' works have been completely liquidated, thus making it essential for consumers to continue to make their purchases in the Midlands, where adequate supplies are available. There is quite a strong call for this type of iron, and though fresh tonnages are only procurable by licence, the current output should be sufficient to permit all users to maintain a steady rate of activity. Similarly with hematite, the demand is about keeping pace with the output, and it is necessary to obtain official sanction before new supplies can be delivered. Local needs are substantial, but producers are also required to meet the demands of consumers in the Birmingham and Sheffield areas. It is frequently suggested that in the near future there will be a further increase in prices, as production costs have risen substantially of late.

**LANCASHIRE**—There is still little material improvement to report in the position of the light-castings trade, most makers being on short time, and the immediate outlook cannot be said to be at all promising. Jobbing foundries supplying machine-tool makers are quite active, but there is a duller tone among some other concerns, although the position of jobbers as a whole has become much better since the outbreak of the war. Heavy electrical engineers continue to take up substantial tonnages of pig-iron, while machine-tool works, too, are in the market for large deliveries. There is a moderate demand from textile machinists. Fair tonnages of West Coast hematite are moving into consumption.

**MIDLANDS**—Foundries in this area are receiving quite good deliveries of iron, although in certain instances the grade of iron specified on the order-sheets is not delivered. Naturally, consumers engaged on Government contracts are receiving first consideration, but supplies are often found for ordinary domestic users. Low-phosphorus iron and hematite are in chief demand. The call for high-phosphorus iron, largely from the light-castings trade, is only fair, many concerns being still on short time, owing to the difficulties experienced in disposing of their products as a result of the quietness of the building industry and the loss of certain export customers.

**SCOTLAND** — Intermittent working among makers of light castings is still reported, but most other iron consuming concerns are busy, taking up large tonnages. Three to four days a week is common among the former and trade in the Falkirk district awaits the placing of Government contracts, although few of these are available at present or likely to be awarded for a time. There is no business being done in Cleveland iron, and former consumers of this type of iron are obtaining their needs from the English Midlands.

## Coke

Good deliveries of foundry coke are being made by the coke ovens, and the position has much improved following the disturbed transport conditions in the first few weeks of the year. Most of the larger users have substantial stocks available, as they bought well ahead, but there are still some concerns who are content to buy on a hand-to-mouth basis. Makers are willing to sell ahead up to the end of June, prices paid being those current at the time of delivery. For delivery to Birmingham and Black Country stations, the present price of Durham best foundry coke is 53s. per ton.

## Steel

Supplies of scrap continue to be inadequate, according to most steel producers, and every effort is being made to improve this position by additional imports and other means. Fortunately, shipments of iron ore to the United Kingdom are satisfactory, and supplies are well up to current requirements. Also, the supply of semi-products is expected to be on a much freer scale following an agreement between British representatives and producers in Belgium. The needs of works on contracts of national importance are being met before those of other consumers at home and overseas, but the desirability of expanding the export trade is fully realised and, in fact, has already been accomplished to some extent.

## Scrap

The Minister of Supply has fixed new prices for scrap iron and steel, which show increases of from 5s. to 10s. per ton. Adjustments to meet changing conditions have led to larger increases in a few cases. Details of the revised prices appear on the price-list on page 18, and an article summarising the new Order under which the increases are made is on page 183.

## Metals

Since free quotations for non-ferrous metals, with the exception of tin, in the United Kingdom have been abolished by the establishment of Government control, American prices are now considered as the basis of international dealings. Thus, recent price changes in New York are of additional interest. The American copper price has moved up from 11.25 cents to 11.50 cents per lb., zinc from 5.50 cents to 5.75 cents, and lead from 4.85 cents to 5.10 cents per lb. Upward price movements in metals often foreshadow a similar trend in commodities generally, but in this instance the rise in metals seems to have been largely induced by the publication of monthly copper statistics after a break of six months. These figures revealed that American producers' copper stocks have been reduced from 316,500 short tons to 135,400 tons in the space of six months, and that the trend is still in a downward direction, owing to large deliveries on contracts entered into during the first three months of the war. At the same time, output has been raised by one-third as compared with the level of production last summer. Buying took on a new lease of life following the publication of these figures, although the movement now appears to have slowed down somewhat.

It is reported from New York that France is to purchase an additional 75,000 tons of copper at 11¼ cents per lb. from the same group of producers from whom 25,000 tons were bought on February 10. The value is about $19,320,000, and the participants are the Anaconda, Kennecott, Haut Katanga and Cerro de Pasco companies, which will supply copper from their foreign properties. International Nickel is also understood to be participating in the order.

The copper position in the United Kingdom is little changed, consumers continuing to take as much as is offered by the Ministry of Supply, while some users are definitely pressing for additional deliveries.

According to Mr. W. H. Gartsen (Henry Rogers, Sons & Company), the total visible supply of tin on February 29 was 23,865 tons, a decrease of 933 tons on the month. The carry-over in the Straits Settlements was 4,168 tons, against 4,998 tons on January 31, while the carry-over at the principal European smelters was 4,689 (5,041) tons.

Tin circles are now waiting to see the effect of the recent cut in the tin quota. America bought quite freely following the decision, but there has been less activity of late, although before long it is expected that the demand will have to open out again. According to the American Bureau of Metal Statistics, re-exports of tin during January totalled 1,500 short tons, against 1,229 tons in December. It is estimated that 75 per cent. was sent to Russia.

Metal market prices for tin were as follow:—

*Cash*—Thursday, £254 to £254 10s.; Friday, £252 15s. to £253 5s.; Monday, £251 15s. to £252; Tuesday, £254 5s. to £254 10s.; Wednesday, £255 to £255 5s.

*Three Months*—Thursday, £253 5s. to £253 15s.; Friday, £252 10s. to £252 15s.; Monday, £251 10s. to £252; Tuesday, £253 10s. to £253 15s.; Wednesday, £254 to £254 10s.

On Thursday last the Non-Ferrous Metals Control delivered warrants for lead and spelter against cash to members of the London Metal Exchange taking up these metals. Both of these metals are in heavy demand and applications for licences are for substantial tonnages. High-grade and g.o.b. spelter are in particularly keen demand, and the Ministry of Supply is having to discriminate carefully in the allocation of available supplies.

It was announced on Thursday last that the Ministry of Supply has made arrangements with the British Aluminium Company and the Aluminium Company of Canada for substantial increases in the output of aluminium in the United Kingdom and Canada. In Canada, for instance, the increase in output is sufficient to make the total capacity of that country alone almost equal to that of Germany. The Ministry has also purchased the entire output of the British Aluminium Company for 1940, and of the Canadian concern up to the end of next year, less only that required for consumption in Canada and for fulfilling certain pre-war commitments. Basic prices approximately equal to those current in the United Kingdom and Canada before the war have been agreed upon.

### Welding Electrodes

A new stainless steel, known as "Stainweld D," has been developed by the Lincoln Electric Company, Limited, Welwyn Garden City, Herts. It is used for arc welding stainless steel of the 25 per cent. chromium, 20 per cent. nickel type. The company has also produced a high-manganese electrode designed for building up worn manganese steel parts of the 11 to 14 per cent. manganese type; it is to be known as "Manganweld B."

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